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The Fifty-First Meeting of the American Astronomical Society

By DEAN B. McLAUGHLIN

The fifty-first meeting of the American Astronomical Society was held in affiliation with the Boston meeting of the American Association for the Advancement of Science, of which Professor Henry Norris Russell is president. Sessions for papers were held at the Harvard Observatory, beginning Thursday afternoon, December 28, and ending Saturday noon, December 30. This is the third time in four years that the Society has met at the Harvard Observatory, and Director Shapley has issued a standing invitation to meet there whenever invitations elsewhere are lacking. Meetings at Harvard are enjoyed by all concerned, but it is hoped that the privilege will not be abused and that a decline of invitations will not result.

Thursday noon found a number of astronomers gathering at the Continental Hotel, Cambridge, to obtain rooms, so far as they were available, to eat luncheon, to keep warm, and to talk and "kill time" until they sallied forth into near-zero weather for the walk of several blocks to the Observatory, through narrow trenches dug in the snow. A meeting of the Council was held at one o'clock, and the first session for papers began at two in the auditorium of Building D, which was crowded to capacity by the time the session was well under way.

At the end of the session the astronomers found their way through the maze of corridors to a very pleasant reception by Director and Mrs. Shapley at the Observatory Residence. Tea, sandwiches, and cakes were consumed in appalling quantities, and much conversation was emitted and absorbed.

The writer did not remain in Cambridge that evening, but from a reliable source of information (none less than the Secretary) he learned that the evening was uneventful. It was too cold to go out, so members gathered about the ash-trays at the Continental Hotel and whiled away the hours in conversation, both general and technical, and in spinning yarns.

On Friday morning the Boston area awoke to the coldest day on record. A minimum temperature of —16° F was recorded during the night, and the maximum during the day was —8°. The Council met at nine o'clock and the sessions for papers began about nine-thirty. At the end of this session the group photograph was taken in the auditorium, as the weather was not conducive to pleasant facial expressions out of doors. Those who occupied the last row of chairs put the massive vol-

umes of a periodical to use to raise them high enough to permit their faces to appear in the picture. The Greenwich Observations would have served even better for this purpose, but they were not in evidence when needed.

Earlier in the session it had been suggested that arrangements be made with a caterer to furnish lunch for the Society, and thus avoid the long trek back to the Hotel. Whether the caterer declined, on the grounds that the coffee would be frozen en route, is not known. At any rate, it was announced later that the Society would be the guests of the Harvard Observatory, without charge, at a luncheon consisting of "coffee and sandwiches, coffee and cakes, coffee and fruit, and coffee." This was greeted with more applause than any of the scientific papers. The luncheon was served in a basement room beneath the files of photographs. What with the enormous weight of galaxies and meta-galaxies overhead, the ceiling required considerable support. It is well that a recently legalized beverage was not served, for if it had been, possibly several astronomers would still be wandering about in that room, colliding with the pillars. The few who left the Observatory grounds during the noon intermission did so for the purpose of getting their cars to heated garages,—and not under their own power.

At the session for papers that afternoon Dr. Paul W. Merrill's retiring vice-presidential address on "Invisible Starlight" was read by Professor Duncan, and several other papers were presented. An appeal for shorter presentations was made by the Secretary, who explained (meanwhile wearing his best poker face) that it was recognized that, to one person at least, each paper on the program was the most important. It is remarkable to see how, under pressure, authors can present the same material in fewer words and shorter time.

The dinner was held,—or, more accurately, eaten,—that evening at the Harvard Faculty Club. The Secretary and the writer made the journey from the Observatory to the Club in three stages, thawing out at the Continental Hotel, and stopping at Memorial Hall where the custodian, who spoke with a South Boston accent, was slightly annoyed to find that anyone had entered after the place was theoretically closed. Conversation on the way turned on the subject of detecting freezing of the face by continually "making faces," a practice indulged by some arctic explorers. The unpleasant thought obtruded itself that one might not be recognizable if his face should freeze in some particularly horrible grimace.

At the Faculty Club, by the time everyone was fairly well thawed, it was announced that dinner was ready. It speaks well for the manners of astronomers that Andrews had to threaten to lock the doors if they did not accelerate their motion towards the dining room. After the dinner, instead of boring one another with speeches, the members of the Society took turns, by table groups, at entertaining the rest of the gathering. Space does not permit mention of all the charades and skits that were enacted, but an account of the meeting would not be complete

without including the murder trial. The absence of the Treasurer had been noticed, but the Society received a severe shock when the Secretary was arrested on a charge of murdering the Treasurer and absconding with four million dollars of the Society's money, besides the Annie J. Cannon prize fund. Pitman, as bailiff, swore the witnesses: "Do you swear not to tell the truth or anything of the truth, so help you Shapley?" All of them did, except Stewart, who was not in the habit of swearing, but was willing to affirm. In the course of the trial several interesting facts, and several astounding ones, were brought to light: that nobody else could possibly look like either the Secretary or the Treasurer; that Abbé Lemaitre disclaimed any belief in the expanding universe; that the Secretary was in the habit of associating with notorious characters, particularly one by the name of H. N. Russell; and that the prosecuting attorney objected to the weather (this objection was sustained). This, and other evidence appeared so conclusive as to the guilt of the defendant that the verdict of "not guilty" was a complete surprise. Probably what remained of the four million dollars was used to "fix" the jury.

The last session for papers was held Saturday morning. Although the program was crowded, it was entirely disposed of without too drastically curtailing the time allowances for presentation or cutting out discussion. It is recorded with satisfaction that no speaker during the entire meeting *conspicuously* exceeded the time allotment of his paper. Perhaps most of them had actually put into practice the Secretary's suggestion that they "hold a rehearsal in the dome and then honestly try to make allowance for the enthusiasm engendered by an attentive audience." The advantage of arranging the papers in groups according to subject was well shown by the manner in which some papers on variable stars, presented at the last session, "dovetailed" almost as if by mutual agreement among the authors.

The Saturday morning session completed the scheduled program of the Society. The Whitin Observatory at Wellesley was open to all comers on Saturday afternoon. What with the cold weather, few felt like venturing so far from Cambridge, but Miss Allen, Smiley, and Pawling are accorded honorable mention.

On Saturday evening, at a joint meeting of the Association and the American Academy of Arts and Sciences, the Rumford medal of the Academy was presented to Dr. Harlow Shapley. We may next hear that he has been prosecuted for hoarding gold. Following the presentation Dr. Shapley delivered an address on "The Anatomy of a Disordered Universe," and disordered accounts of the address were printed in the newspapers.

The Council admitted sixteen new members and elected Professor Albert Einstein to honorary membership. The committee on the Annie J. Cannon Prize reported to the Council, and the rules governing the award of the prize were read to the Society. They are as follows:

1—The prize is to be designated as the Annie J. Cannon Prize in Astronomy.
2—It shall be awarded to women for distinguished contributions to astronomy or for similar contributions in related sciences which have immediate application to astronomy.
3—The prize shall be open to women of all countries.
4—The award shall be by the Council of the American Astronomical Society and shall be announced at the December meetings of the Society.
5—The award shall be first made in December, 1934, and thereafter at intervals of three years subject to the judgment of the Council. The award may be omitted at any time at the discretion of the Council.
6—The prize shall consist of a token or certificate and of a money award determined by the Council. Only accumulated interest shall be used for the prize, the principal fund remaining intact.
7—The American Astronomical Society shall be the custodian of the fund which shall be invested by the Treasurer of the Society on the advice of the Finance Committee.

During the sessions for papers the chair was occupied part of the time by Dr. Shapley, Vice-President of the Society, or by Dr. V. M. Slipher, Chairman of Section D. At various times during the meetings each member of the Council who was present (except the Secretary, who was always otherwise occupied) was given an opportunity to preside long enough to find out what it was like, but not long enough to quench a desire to be President at some future date.

Professor Frederick Slocum was elected Chairman of Section D for the coming year.

Forty papers were presented during the four sessions. The program was characterized by the usual variety and seemed definitely more interesting than at an average meeting. Probably the hardest-worked member was Dr. J. S. Plaskett who, as the sole representative of the Dominion Astrophysical Observatory, was entrusted with the presentation of five papers from that institution.

The writer will not attempt to summarize all the papers, but some of novel or outstanding character should be mentioned. Gradually the hiatus between the dimensions of our galaxy and of spiral nebulae is being closed, what with photographic extension of the boundaries of spiral nebulae, reported in a paper on the diameters of galaxies by Shapley, and photo-electric detection of outlying parts of the Andromeda nebula by Stebbins and Whitford. A new solution for the position of the galactic center, by Plaskett and Pearce, gives a distance of 9900 parsecs. This was based on the galactic rotation effect of the class B stars. Not so very remote from this same question is the problem of the stability of a moving cluster, under the tidal action of the massive galactic nucleus, discussed by Bok, who assumed, for purposes of calculation, a value of 10,000 parsecs for the distance of the sun from the

center,—a guess practically identical with the value resulting from long and painful calculation.

The perennial problem of coronium may soon be unravelled; Boyce, McKellar, and Menzel suggested that several of the coronal lines are due to oxygen. But that element which is the cause of so much worry to astronomers seems to be lacking in the atmosphere of Mars. Tests for the intensification of the B-band in the spectrum of the earth-shine on the moon were reported by Dunham, who found that the band was intensified as it should be, due to the longer path through the earth's atmosphere than in the case of direct sunlight. Hence the absence of the oxygen band in the spectrum of Mars cannot be ascribed to scattering of that frequency by the Martian atmosphere. The use of silver as a coating for astronomical mirrors is now on the decline. Boothroyd reported on the Cornell expedition to the Lowell Observatory. About 200 spectrograms of stars were obtained with aluminum-coated mirror and quartz spectrograph, showing the spectra as far as the limit of transmission of the earth's atmosphere.

Alter presented a paper on the problem of origin of the solar system, in which an encounter with another star does not figure. V. M. Slipher reported on further studies of the spectrum of the night sky, and presented a paper by E. C. Slipher on the white spots which appeared on Saturn last August. There were numerous papers on spectroscopy, photometry, parallaxes, and other subjects, but the reader is referred to the *Publications* of the Society which will appear in the near future.

The fifty-second meeting will be held at Connecticut College, New London, Connecticut, in September, 1934, and the fifty-third at the Franklin Institute, Philadelphia, in December. After that it would appear fitting and proper for some middle-western observatory to extend an invitation.

Notes on Stellar Photography

By HORACE C. LEVINSON

The following pages contain some notes on stellar photography with wide-angle lenses, assuming only very ordinary equipment of the sort available to most amateurs. In particular, the adjustment of the equatorial mounting is discussed in some detail. The standard methods, given in works on Practical Astronomy, make considerable demands in the way of instrumental precision, which it may be difficult for the amateur to meet. The method suggested here seems to have particular advantages under these conditions. The accuracy required in this adjustment depends on the length of the exposure; this will be given numerically for exposures of various lengths.

These notes are based on the writer's experience many years ago with very simple equipment, and were in fact written in outline before the war. Their appearance at this late date, in revised form, was decided on in the hope that they may have some value to amateurs wishing to

take up this interesting work, and to those in the process of mastering its technique. The photographs reproduced here were made during the last few months with the same instrument as was used formerly.

As more than half of this paper is devoted to the particular problem referred to above, it has been necessary to omit discussion of many interesting phases of the subject,[1] and in particular the entire matter of the handling and use of the plates subsequent to exposure.

Without further preliminaries we shall consider the equipment necessary for wide-angle stellar photography, assuming only the minimum that seems requisite to a certain degree of success. This equipment consists essentially of three parts, a telescope for guiding, an equatorial mounting with clockwork of some sort, and a camera to be attached to the telescope tube, or to the declination axis of the equatorial. We shall consider them in the order given.

The telescope, since it is used only for guiding, need have only the most ordinary optical quality, and if its focal length is four or five times that of the camera lens, it is more than ample, and a low-power eyepiece can be used. In general it is sufficient to use an eyepiece such that the magnification of the telescope is three times the focal length of the camera lens, expressed in inches; this means that the focal length of the eyepiece in inches equals one third the ratio of the telescope focus to the camera focus. For stellar photography a telescope of small aperture is ordinarily all that is required, since it is usually possible to select a fairly bright guide star. With an aperture of three inches guiding on a star fainter than magnitude six is difficult. In the case of most comets, however, the advantage of a larger aperture is very great.

The equatorial mounting is of the greatest importance; on it will usually depend the success of the undertaking. It must be equipped with slow motions in both right ascension and declination, and a clock capable of following with fair accuracy. The more skilled the observer in guiding the less accurate need be the clock: but guiding with a poor clock is very fatiguing, and the probability of success is decreased. The mounting must be rigidly supported, preferably by an iron pillar, resting on a concrete foundation set several feet into the ground. If the instrument is provided with a shelter, the latter should have a sliding roof, not a dome with slit, since wide-angle lenses are to be used. In this case subsequent problems are simplified, for, once the polar axis is set parallel to that of the earth with sufficient accuracy, the movable parts used in the adjustment can be rigidly and permanently clamped.

We shall assume, however, that the instrument is not provided with a permanent shelter, but must be taken apart and removed indoors, at least a part of the time. In this case it is essential to provide means for returning the polar axis to its previous position, within narrow limits of error. Otherwise it would be necessary to adjust this axis each time the

[1] See Dr. Hale's book "The Study of Stellar Evolution," Chapters V and XXV, which contain also a high appreciation of amateur work in the history of astronomy.

instrument is set up, a quite impracticable undertaking, except for very short exposures. One way to overcome the difficulty is as follows: The rotation in azimuth of the equatorial head on the upper surface of the pillar is restricted by a pin set in the latter, received by a circular slot, a few degrees in length, in the head. At one end of this slot is a horizontal screw, which comes into contact with the pin when the head of the equatorial is rotated in the appropriate sense. During the adjustment of the polar axis in azimuth this contact is maintained, thus serving to mark its position, so that when the instrument is dismounted it can be set up again with the required accuracy.

In case a tripod mounting is used it is best to set three small concrete blocks with iron hoofs to receive the legs; the tripod top can be equipped as indicated in the preceding paragraph for the iron pillar. It is not to be expected that such an arrangement will keep the polar axis accurately in adjustment, but it is adequate for short exposures.

A few remarks concerning the choice of a lens will be included. The ideal lens would be one with a large flat field and great speed. The latter depends on the ratio of the aperture to the focal length; the reciprocal of this quantity is usually denoted by f, and a lens, for example, of two inches aperture and eight inches focus, is said to work at $f4$. The theory of the many aberrations of the images formed by systems of lenses shows, however, that the greater the speed of the lens the more difficult it is to obtain a large flat field. In practice a lens working at $f5$ or faster, that defines stellar images satisfactorily over a field 15° to 20° in diameter, is doing all that can be required of it. As an illustration, consider the aberration known as the curvature of the image. The image of a plane, instead of being plane, lies on a curved surface, normally concave towards the lens. Suppose that the photographic plate is placed tangent to this surface where it intersects the axis of the system, so that the center of the plate is in focus. For a given type of lens system the curvature of this surface decreases in general the farther it is from the lens, so that the separation of the surface and the plate, as the edges of the field are approached, is less the longer the focus. In other words, the slower the lens the less difficult the correction.

A reasonable compromise must be effected between the extremes. Among commercial lenses those of the portrait type meet the requirements the best. The amateur will usually select one working at $f5$ or faster, unless he is prepared to make long exposures. The effects that depend on the size of the aperture are given by the theory of lenses, and are briefly as follows: In the case of an extended object, a nebula for instance, no system of lenses can increase its brightness. The intensity of the image, however, is proportional to the square of the ratio of aperture to focal length, so that, neglecting minor losses of light by reflection, absorption, etc., it is the speed of the lens and not its aperture that is pertinent in this case. On the other hand, when we take into account fine detail in an extended object, or consider stellar images, we have to do with diffraction images, which are smaller with larger aper-

tures. In photographing a nebula greater detail is therefore shown when the aperture is increased. The intensity of the image of a star is proportional to the ratio of the fourth power of the aperture to the square of the focal length. Thus the larger the aperture the fainter the stars that can be photographed with given exposure. Furthermore, the limiting magnitude that can be photographed with any exposure depends on the aperture. At this limit the intensity of the star image is equal (or nearly so) to that of the sky. It is clear that this limit exists, since the sky plays the part of a luminous extended object.

We shall suppose now that the instrument is set up, either in a permanent shelter or arranged, as described above, so that it can be brought back to the same position each time it is assembled. It is necessary to adjust the polar axis quite accurately parallel to that of the earth. If this is not done, and the guide star is kept exactly at the center of the field during a fairly long exposure, the star images on the plate will be round dots only in the vicinity of the guide star. At other places the images will be arcs of circles, the length of the arc being proportional to the distance of the star from the guide. In other words, the plate will have been in effect slowly rotated about the guide star during the exposure. To see that this is so consider the point on the celestial sphere where the polar axis of the instrument cuts it if prolonged. Call this point I; it is near but not coincident with the true pole P. Now the equatorial, if driven by an ideal clock running at the correct sidereal rate, will follow, not the path of a star as it actually moves, but its path as it would move if it were revolving about the point I instead of the point P. To keep the guide star on the cross-wires it is necessary to make corrections in both right ascension and declination, which cause this star to occupy a fixed position on the plate. But by the fundamental properties of the equatorial mounting the plate, which is rigidly attached to the mounting, keeps its orientation unchanged relative to the instrumental pole and not the true pole. The effect of the corrections referred to above is thus to cause the plate to rotate about the point occupied by the guide star.

It is of interest to know the amount of this rotation under given conditions, as it gives us a clear idea of the accuracy necessary in adjusting the polar axis of the equatorial. This is easily obtained by solving the appropriate spherical triangle. From the solution follow the properties mentioned below. Since certain of the quantities that enter are always small in practice, we can, for numerical purposes, simplify the formulae by using an approximation. We shall give such formulae as briefly as possible before proceeding to the numerical results, asking the indulgence of those readers not familiar with spherical trigonometry.

Let d be the distance between P, the true pole, and I, the instrumental pole; d is the error in pointing the polar axis. Denote the polar distance of the guide star by p,[2] and its hour angle by h, measured in the usual

[2] We assume that p is less than or equal to 90°. When p is greater than 90° it is clear that d is to mean the error relative to the *opposite* pole.

sense in degrees from 0° to 360°. Let the hour angle of I be h_0. Let A be the angle between two great circles, one containing the guide star and P, the other the guide star and I. The change in the angle A measures the rotation of the plate. A is zero for $h = h_0$, as the great circles mentioned above are then identical. In practice d is always small, so that for numerical purposes sin d will be replaced by d. The value of A can then be expressed:

$$A = \arctan \frac{\sin \tfrac{1}{2}(h - h_0) \cos \tfrac{1}{2}(h - h_0)}{\sin \tfrac{1}{2} p \cos \tfrac{1}{2} p} d.$$

For $p = 90°$, that is for stars on the equator, this formula becomes exact if d is replaced by tan d. If p is not small the approximation is entirely satisfactory. If p is small, as well as d, the relative error is of the order of d/p. If d is less than, say 12′, and it is required to determine A with a maximum error of 10%, p must be greater than 2°.

The exact formula for A, which is not stated here, gives us the following information: The numerical value of the rate of the rotation has relative maxima at $h - h_0 = 0$ and $h - h_0 = 180°$, the value of the former being slightly the greater. The sense of the rotation changes for $h - h_0 = 90° + m$ and $270° + m$, where m is a small angle, for d small and p large, which is zero for $p = 90°$. Also A is an odd function of $h - h_0$; that is, if the sign of the latter is changed, A changes sign, keeping the same numerical value.

If we note that in practice the angle A is always small, we can simplify the formula further by replacing tan A by A. Solving for d we thus get

$$d = \frac{\sin \tfrac{1}{2} p \cos \tfrac{1}{2} p}{\sin \tfrac{1}{2}(h - h_0) \cos \tfrac{1}{2}(h - h_0)} A.$$

This formula tells us the value of d, *i.e.* the error in adjustment of the polar axis, that corresponds to a given rotation of the plate for a given guide star. Since in practice we do not in general know the value of h_0, we must use values of $h - h_0$ such that for the corresponding exposure, d is a minimum. From the above properties of A as a function of d and $h - h_0$ it is easily seen that d is a minimum when the middle of the exposure it at $h = h_0$. Since d is an odd function of A we need consider only exposures beginning at $h = h_0$. Then for an exposure of twice the length with mid-point at $h = h_0$, the required minimum value of d is one-half of the computed value. For example, if we wish to know how accurately the polar axis must be adjusted in order that the rotation of the plate be less than a given amount for a given guide star, with an exposure of, say, two hours, we compute the value of d for $h - h_0 = 15°$, and take half of the result.

Let s be the length of the arc described by a star distant a inches on the plate from the guide star, due to the rotation of the plate. Then $A = s/a$. The focal length of the camera lens does not enter here because we have considered the angular rotation of the plate instead of the

corresponding displacements on the celestial sphere. In order to obtain numerical results we must give a value to s corresponding to the maximum permissible displacement of a stellar image. We select $s = 1/400$ in. $= 2.5 \times 10^{-3}$ in. We assume that the edge of the field is one and one-half inches from the guide star, and therefore take $a = 1.5$ in. Then $A = 1.67 \times 10^{-3}$ radians $= 5.74$ minutes of arc.

Let us consider exposures of two hours each on stars at various polar distances, the middle of the exposures being at $h = h_0$. The following table gives the result of substituting these values of A and $h - h_0$ in the formula, for the indicated values of p:

p	d	p	d	p	d
5°	′96	40°	7′.2	70°	10′.4
10	2.0	50	8.5	80	10.9
20	3.8	60	9.6	90	11.1
30	5.5				

Thus if the guide star is, for example, at +20° declination, the polar axis must be adjusted to within 10′.4 of the true pole in order that, during an exposure of two hours, star images within one and one-half inches of that of the guide star shall not show a displacement of as much as 1/400 in.

It may be of interest to indicate as well the numerical results for exposures of various lengths. The following table gives values of d for three positions of the guide star, and for the indicated exposures:

Exp. (hrs.)	$p = 5°$	$p = 45°$	$p = 90°$
½	3′.8	31′.0	43′.9
1	1.9	15.5	22.0
2	.96	7.9	11.1
4	.50	4.1	5.7
6	.35	2.9	4.1

These results show that for long exposures in general and even for short ones near the pole it is essential that the error in pointing the polar axis be at most one or two minutes of arc. They show equally that short exposures near the equator are feasible with only a very crude adjustment.

If the equatorial is equipped with accurate circles and verniers the adjustment of the polar axis can be accomplished by the standard methods given in treatises on Practical Astronomy.[3] In case, however, the circles are crude it is necessary to have recourse to special methods. One such method is given by Chauvenet.[4] The one given here has been used by the writer, leads to a sufficiently accurate adjustment, and has the great advantage of requiring relatively little time, so that it is possible to verify the adjustments and push the approximation farther by repeating the process at once. The method given by Chauvenet, on the other hand, requires four observations at six hour intervals, and leads to a numerical determination of the errors in altitude and azimuth of

[3] W. W. Campbell: Elements of Practical Astronomy; 2nd ed., p. 214.

[4] Wm. Chauvenet: Manual of Spherical and Practical Astronomy; 5th ed., Vol. II, p. 388.

the polar axis. It is then necessary to make the indicated corrections. But to do so requires the means of accurately measuring small angles, so that it would appear that the advantage of getting along without accurate hour and declination circles is offset by this disadvantage. In fact, it is clear that only a method involving trial and error will avoid the difficulty.

Assume that the equatorial has crude circles, and that its axes are perpendicular to each other. The first operation is to set the polar axis at an inclination approximately equal to the latitude of the place of observation, and then to bring its plane roughly into the plane of the meridian. This may be done by leveling the declination axis and bringing a star to the center of the telescope field at the instant of its meridian passage by swinging the entire equatorial head in azimuth.

The second step is to carry the adjustment as far as possible with the circles. This is not at all essential to the third step, but corrects the index error of the declination circle. One standard approximate method is essentially as follows:[5] Readings of the declination circle are taken with the telescope in the two positions, 180° apart, on a star very near the meridian. Half the difference of these readings is the index error of the declination circle. When this is corrected the polar axis is raised or lowered, as the case may be, until it reads correctly the declination of the star, corrected, if necessary, for atmospheric refraction. A northern star whose hour angle is about $\pm 6^h$ is next selected, the telescope set to its declination, corrected for refraction, and the head of the equatorial swung in azimuth until the star can be brought to the center of the field by swinging the instrument in right ascension only. This completes the adjustment, which can be repeated for further accuracy. With crude circles the corrections for refraction are unnecessary.

The third step is the one referred to above, and does not depend on the circles. For the greatest accuracy it will be necessary to make fairly accurate estimates of small angles in the sky, so that, in the absence of a micrometer, it will be best to provide the eyepiece with two cross-hairs, their distance apart being two or three minutes of arc. This can be measured by timing the passage of an equatorial star. Or a single coarse wire will do, its measured diameter serving as a basis for estimates. The method is as follows: Pairs of stars are found by the aid of the *Nautical Almanac*, whose declinations, for the epoch in question, are very nearly the same. The right ascensions should differ by from two to five or six hours. One set of pairs should be fairly near the pole, the other set far from it.

Select a pair of southern stars and at the hour when their hour angles are equal but of opposite sign set the cross-wires accurately on one of them, say the eastern one, and clamp the instrument in declination. Upon swinging the telescope to the western star it will be found in general either north or south of the wires. In the latter case it follows that the

[5] Elias Loomis: An Introduction to Practical Astronomy; 7th ed., p. 28.

polar axis is pointing too far to the east, and the mouning must be rotated so that the southern end of the polar axis moves east. In the former case the mounting must be rotated in the opposite sense. The amount of the rotation should be such that the apparent north or south deviation of the star that is now in the field is reduced to one-half its former value. If the difference in declination of the two stars is appreciable it must be allowed for; the apparent deviation of the second star is increased or decreased by this difference. Hence the necessity for estimating small angles. For example, if the declination of the western star is the greater (north polar distance less), and its deviation is to the north, the latter is to be decreased by the difference in declination of the stars. If its deviation is to the south it is to be increased by this difference. But it is important to note that no correction for atmospheric refraction is necessary. For the two stars are at the same altitude, so that its effect is merely to shift both stars apparently to an adjacent declination circle.

When the correction is made the operation is at once repeated, and is continued until the second star shows no appreciable deviation north or south of the wires (allowance being made for the difference in declination of the stars, as indicated above). As each operation requires a few minutes to carry out, and as the stars can be in the specified position but once each day, it is best to begin the adjustments well ahead of the exact hour, so that the error may be brought down to a small amount in time to make a final setting when the hour angles are numerically equal.

The polar axis is now very nearly in the plane of the meridian. It remains to bring it more accurately to the proper elevation. To this end we select one of the northern pairs, making the observations at the hour when the stars are at equal distances from one or other of the hour circles $E6^h$, $W6^h$. The operations carried out on the southern pair are repeated, with the exception that corrections are made in the elevation or altitude, instead of the azimuth of the polar axis. Suppose for definiteness that the average hour angle of the stars is $E6^h$, and that we set the *following* star on the wires and swing to the *preceding* star. Then if the latter is to the north of the wires, after allowing for the proper corrections, the polar axis is pointing too high, in the contrary case too low. If the stars are in the west instead of the east the above conclusions are reversed. We raise or lower the axis by such an amount as to take up one-half of the apparent error until the latter disappears. The same remarks apply regarding the time of the observations as in the other case. In making this adjustment, however, atmospheric refraction must be allowed for. The apparent deviation of the second star is to be corrected for the difference in the declination components of the refraction for the two stars. If the stars are not more than three hours apart and fairly near the pole, this amount is small. It is to be noted also that this second adjustment could equally well precede the first. Further accuracy is attained by repeating the entire process, using the

same or other pairs of stars.

Instead of giving the exact equations that justify the use of this method, which are of little interest, we stop only to inquire what order of accuracy is to be expected from it, and for this purpose a simple numerical example will suffice. Suppose that the polar axis has already been adjusted in altitude, and that its error in azimuth is small enough so that we may consider the hour angle of the instrumental pole I to be $\pm 6^h$. Let d be the distance PI, as before, and let h be the hour angle of one of the stars, $-h$ that of the other. Take the common declination of the stars as 0°. Let D be the instrumental difference in declination, positive if the western star appears south of the wires, negative if the opposite case. Then

$$\sin \tfrac{1}{2}D = \pm \sin d \sin h,$$

the plus sign corresponding to the case where the hour angle of I is -6^h, the minus sign to the other case.

Suppose that the stars are three hours apart in right ascension; then $h = 22° 30'$. For $d = 10'$ we find that $D = \pm 7' 40''$; for $d = 1'$, $D = \pm 47''$. Thus we see that under these conditions the error in the setting of the polar axis is not much greater than our limit of accuracy in comparing the apparent declinations of the two stars.[6] With sufficient care and without the use of a micrometer it should be easy to reduce the error to less than 30 seconds of arc.

The following list contains examples of pairs of stars suitable for the purpose. Their difference in right ascension is indicated by $\Delta\alpha$, that in declination by $\Delta\delta$. The column headed M (for Mid-Point) gives the right ascension of the hour circle midway between those containing the stars. The data are taken from the *Nautical Almanac* for the epoch 1933.0.

	$\Delta\alpha$	$\Delta\delta$	M
Northern Stars.			
	h m	″	h m
γ Cassiop.			
10 Camelop.	4 5	27.8	2 55
47 H Cephei			
19 H Camelop.	1 14	8.0	4 04
36 Ursae Maj.			
ε Ursae Maj.	2 25	5.3	11 38
4 H Draconis			
ζ Ursae Min.	3 37	47.0	13 58
Southern Stars.			
	h m	″	h m
13 Ceti			
25 Monocer.	7 2	3.3	3 33
ζ Geminorum			
η Cancri	1 29	0.6	7 45
α Hydrae			
m Virginis	4 14	6.6	11 31
γ Herculis			
γ Sagittae	3 37	0.5	18 7
ξ Herculis			
α Trianguli	7 54	2.9	21 52

[6] If the stars are six hours apart D is approximately equal to $\pm d$.

The focus of each lens to be used must be determined with particular care. As a rough first approximation the visual focus as determined with a ground glass may be used. The necessary correction depends on the particular manner in which the lens has been corrected for chromatic aberration, as well as the fact that in general the ground glass will be out of register with the plate. This correction is best accomplished by the standard method of star trails; several exposures can be made on the same plate. After the most effective focus for the center of the plate has been found it is best to experiment with short exposures with the plate very slightly nearer the lens, as under certain conditions this will lead to better results. When the plate is in this position there is in general a ring of in-focus images a short distance from its center. This procedure is of particular value in the case of very fast lenses.

The standard method of guiding is by use of illuminated cross-hairs, bisecting the image of the star in two directions. With a low power the star image is too small, and should be thrown slightly out of focus. In the absence of an illuminated eyepiece the threads should be coarse enough to be clearly visible when guiding on faint stars. To facilitate the slow motion corrections the eyepiece should be rotated so that the threads run north and south and east and west.

In the case of extremely bright comets a similar method can be used, the nucleus taking the place of the star image. Guiding on fainter comets is difficult at best, and particularly so in the absence of illuminated cross-hairs. Perhaps the following method will be found serviceable, although I have not used it sufficiently to recommend it without hesitation. If the comet has a fairly well-defined coma the telescope is so pointed that one of the east and west and one of the north and south wires are tangent to its circumference, and that the motion of the comet carries it toward one or both of the wires. If the comet is moving northeast, for example, it should be placed in the southwest quadrant. In this way its most frequent apparent deviation from its initial position is in the direction of partial obscuraton by the wires, which is easy to detect and correct. Very coarse wires should be used.

The accompanying reproductions are of plates made by the writer with equipment similar to that assumed in this article; a 3-inch refractor for guiding, an iron pillar with concrete foundation, supporting a Gaertner equatorial with spring clock, provided with a device similar to that mentioned above to insure that the polar axis return to its previous azimuth after the instrument has been dismounted. The lenses used are as follows: a Voightländer portrait lens of 4 inches aperture (more accurately 10 cm), and focus of 20 cm, therefore working at *f*2, and a Goerz Celor of 2 inches aperture (more accurately 1.9 in), working at *f*5.

The 4-inch Voightländer was once the property of the Yale Observatory. It was used for a time, so Dr. Elkins informed me, in two-station meteor work, but its field is too small for the purpose. The project was soon abandoned for other reasons. The lens defines star images sharply over a circle about 7° in diameter. In this limited field it is very effec-

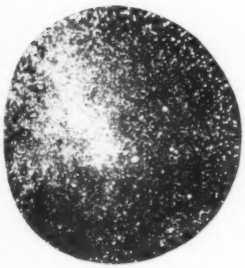

FIGURE 1

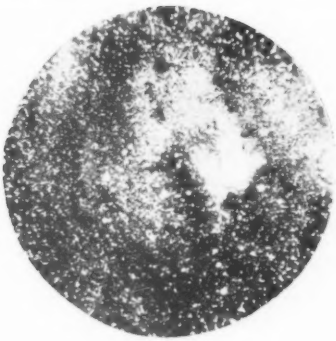

FIGURE 4

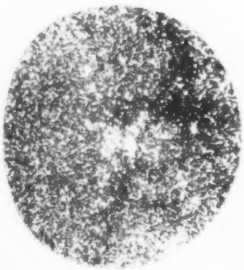

FIGURE 2

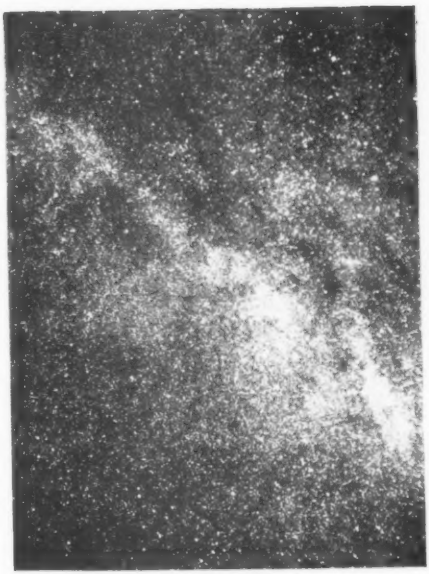

FIGURE 5

FIGURE 3

1—Star Cloud in Cygnus. 4-in. lens. Exp. 40 min.

2—Region of 15 Monocerotis. 4-in. lens. Exp. 4 hr. 15 min.

3—Comet 1932 *h*. Sept. 3, 1932. 4-in. lens. Exp. 2 hr. 30 min. (enlarged).

4—America Nebula in Cygnus (N.G.C. 7000). 4-in. lens. Exp. 1 hr. 40 min. (enlarged).

5—Milky Way in Cepheus. 2-in. lens. Exp. 1 hr. 30 min. (scale reduced).

tive in picking up faint extended nebulosity or the tail of a comet, with relatively short exposure. For example, the nebulosities south of ζ Orionis are clearly shown with an exposure of ten minutes, including the "horse-head" nebula, Barnard 33, while those north of this star are quite bright on such a plate.

Of photographs reproduced herewith perhaps only Figure 3 requires comment. This shows the Peltier-Whipple comet (1932 *h*) on September 3, 1932, the middle of the exposure being at $3^h\,40^m$ G.C.T. On the original plate the length of the tail is about 3°. A one-hour exposure made five days earlier shows the tail to have been at least $3\frac{1}{2}°$ long, with a very pronounced jet about 1° from the head, extending in a direction making an angle of 30° with the tail, measured clockwise. On the original of Figure 3 there seem to be traces of a similar jet at a distance of $1\frac{1}{2}°$ from the head, and at the same angle. In the absence of plates on intervening days it is impossible to identify one with the other with any confidence. Such an identification would indicate a motion along the tail at the rather low speed of about two miles per second.

KENNEBUNK, MAINE.

A Standard-Time Sun-Dial

By LELAND S. RHODES

The usual form of sun-dial does not show standard time for two reasons. First, the position of the sun gives local time, which varies with the longitude of the place while standard time is the same over a wide belt; and, second, the sun is irregular in its apparent motion and may be ahead or behind uniform mean time by as much as 16 minutes. A standard-time sun-dial must therefore take into consideration the difference between local mean solar time and standard time, which difference is a constant and depends on the longitude of the place. It must also take into consideration the difference between apparent solar time and mean solar time, which difference is variable and depends on the time of year. The method of design is best explained by showing the steps of an actual construction. We will therefore follow out these steps for a dial to be located at State College, Pennsylvania, latitude 40° 47′ N, longitude 77° 52′ W.

The first step is to obtain latitude and longitude of the desired location from any reliable map, such as a United States Geological Survey sheet. Since the graduated surface on which the shadow is cast is most conveniently a horizontal plane, we shall use this type. The gnomon, or edge which casts the shadow, must be parallel to the earth's axis, and therefore must make an angle with the horizontal equal to the latitude of the place, or 40° 47′ in this case. So the dial consists of a horizontal surface with graduations to be determined, and a triangular piece fastened to it in a vertical plane, this triangular piece having an angle

of 40° 47′ at its lower corner, shown as the angle ϕ in Figure 1. This angle is most accurately laid out by plotting its tangent.

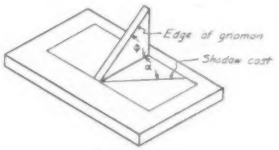

FIGURE 1.

Imagine the sun-dial in place with the gnomon pointing to the true north (parallel to the earth's axis). When the sun crosses the meridian it is apparent solar noon and the gnomon casts no shadow. By 3:00 P.M. the sun has traveled 3 hours or 45° west of the meridian and the gnomon casts a shadow on the horizontal surface, which shadow makes an angle a with the base of the gnomon, as shown in Figure 1. From spherical trigonometry, $\tan a = \sin \phi \tan t$, in which a is the angle between the base of the gnomon and the shadow, ϕ is the angle between the gnomon and the horizontal surface, and t is the hour-angle (or angle of the sun from the meridian, 45° at 3:00 P.M. and at 9:00 A.M.). Let us compute a table for locating lines to read each 20 minutes of time. Column 1 of Table A gives the various hour-angles t, in hours and minutes. Column 2 gives corresponding values of t in degree measure. (Remember that 24 hours = 360 degrees, and 1 hour = 15 degrees.) ϕ in this case is 40° 47′ and $\sin \phi = .653$. Therefore the above formula reduces to $\tan a = .653 \tan t$, a computation readily done on a slide-rule. Column 3 gives these computed values of $\tan a$. For convenience in plotting, values of $\cot a$ are substituted in place of $\tan a$ as soon as $\tan a$

TABLE A.

Hour-angle t			Hour-angle t		
h m	°	tan a	h m	°	cot a
0 00	0	0.000	4 00	60	0.885
20	5	.057	20	65	.715
40	10	.115	40	70	.558
1 00	15	.175	5 00	75	.410
20	20	.238	20	80	.270
40	25	.305	40	85	.134
2 00	30	.377	6 00	90	.000
20	35	.458			
40	40	.548			
3 00	45	.653			
20	50	.778			
40	55	.932			

becomes greater than unity. These a angles should be laid out by plotting their tangents (or cotangents for angles over 45°). When these tangents (and cotangents) are plotted for hour-angles both before and after noon we have the usual form of sun-dial, reading local apparent solar time. This plotting is shown in Figure 2. The width of the space between the two halves of the diagram is of course made equal to the thickness of the gnomon. Figure 2 is a construction diagram only,

and contains lines omitted from the finished sun-dial.

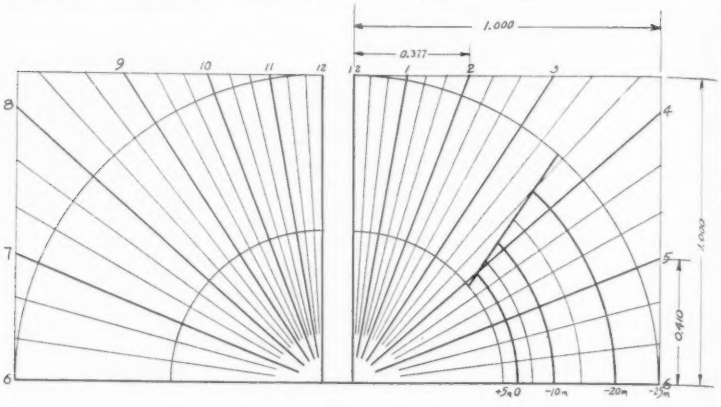

FIGURE 2.

Apparent solar time minus mean solar time is called the equation of time and is the amount by which the sun is ahead (or behind) mean uniform time. This amount varies through the year as shown in column 2 of Table B. (This is the same for all localities and approximately the same for all years.) This table means that on October 20 when it is

TABLE B.

Date	Equation of time	Final correction	Date	Equation of time	Final correction	Date	Equation of time	Final correction
	m	m		m	m		m	m
Jan. 10	—17	—18	May 10	+04	—07	Sep. 10	+03	—08
20	—11	—22	20	+04	—07	20	+06	—05
30	—13	—24	30	+03	—08	30	+10	—01
Feb. 10	—14	—25	Jun. 10	+01	—10	Oct. 10	+13	+02
20	—14	—25	20	—01	—12	20	+15	+04
28	—13	—24	30	—03	—14	30	+16	+05
Mar. 10	—11	—22	July 10	—05	—16	Nov. 10	+16	+05
20	—08	—19	20	—06	—17	20	+15	+04
30	—05	—16	30	—06	—17	30	+12	+01
Apr. 10	—02	—13	Aug. 10	—05	—16	Dec. 10	+08	—03
20	+01	—10	20	—04	—15	20	+03	—08
30	+03	—08	30	—01	—12	30	—02	—13

1:34 P.M. apparent solar time (sun-time), it is 1:19 P.M. mean solar time, because the sun is 15 minutes fast. The longitude of our place is 77° 52′ west of Greenwich, and since 15 degrees equals one hour, this means that our local time is 5 hours and 11 minutes behind Greenwich time. Since Eastern Standard Time is exactly 5 hours behind Greenwich time, our local time is 11 minutes behind standard time. So, when it is 1:34 P.M. apparent solar time and 1:19 P.M. mean solar time at State College, it is 1:30 P.M. Eastern Standard Time. In other words, by applying a constant of —11 minutes to the equation of time, we get the correction necessary to change standard time to local apparent solar

time of State College, as shown in column 3 of Table B. Of course, if the sun-dial should be located east of the standard-time meridian (75° W for Eastern Standard Time), the constant to apply to the equation of time would be plus.

The extreme corrections occur on February 10 to 20, when the sun's hour angle is $3^h\ 35^m$ at 4:00 P.M. standard time; and on October 30 to November 10, when the sun's hour-angle is $4^h\ 05^m$ at 4:00 P.M. standard time. The lines of Figure 2 give the hour-angles of the sun (local apparent solar time) by the different positions of the shadow cast by the gnomon. A standard-time line for 4:00 P.M. must therefore be drawn across all the hour-angle lines from 3:35 P.M. to 4:05 P.M. Then to get standard time from the dial, the position of the shadow must be read on the proper part of this line depending on the time of year. We will

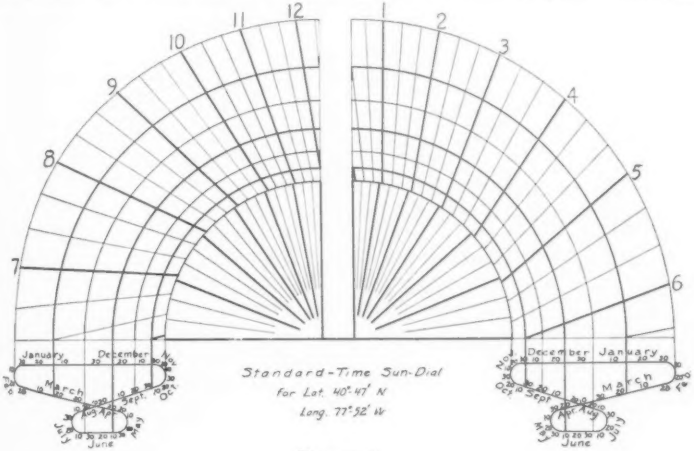

FIGURE 3.

now construct these standard-time lines. First, draw quarters of circles as shown in Figure 2, one radius as large as the diagram permits, and the other radius about half as large. Now draw for the 4:00 P.M. standard-time line a straight line running from the inner circle at a point where the shadow will be at 4:00 P.M. standard time November 10, to a point on the outer circle where the shadow will be at 4:00 P.M. standard time February 10. At State College this would be from 4:05 P.M. on the inside circle to 3:35 P.M. on the outside circle, as determined by column 3 of Table B, and illustrated in Figure 2. Figure 3 shows the same thing done for all the standard-time lines, and with the construction lines of Figure 2 omitted. An actual dial, unless it is very small, is better made by computing and drawing time lines 10 minutes apart instead of 20 minutes apart as shown here.

Now it only remains to plot a date scale to show at any time of the year on what part of the time lines standard time is to be read. First

draw other circles through the standard-time lines, as indicated in Figure 2, at points where the corrections to standard time (to get sun-time) are 0 and 20 minutes, respectively. These points are indicated by the crossing of the standard-time and the sun-time lines. By interpolation the circles at five-minute intervals, as shown in Figure 2, may be drawn. If time-lines 10 minutes apart are used, then these correction circles may be at two-minute intervals. Next construct a figure eight for the date scale as shown in Figure 3. The small loop of the figure eight is governed by the corrections on May 10 and July 20, as an inspection of Figure 3 will show. The other dates of the year can now be plotted around the figure eight as indicated by column 3 of Table B and illustrated in Figure 3. If desired, the solar-time lines may be left inside the inner circle as has been done in Figure 3. The shadow will then give both local apparent solar time and standard time. Figure 3 shows the finished dial graduations. To set the sun-dial for operation, it is necessary only to level the bottom surface by level-bubbles and then to turn it about a vertical axis until the shadow reads correct time. This is best done near noon.

THE PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA.

A Statistical Survey of Solar Eclipses in Chinese History*

By WEN SHION TSU

Throughout the Chinese history there were 920 solar eclipses properly recorded, only seven of them were in error and did not take place. These eclipses which were carried down to the present time makes a good reference to study of the history of Chinese astronomy. Since Shih Ching, Book of Poetry, interestingly informed that "the eclipse of the moon is a common matter and the eclipse of the sun is a bad thing," therefore the first standard history, Shih Chi, written by Szu Ma Chien, the celebrated historian of the Han Dynasty about 90 B.C., rejected the lunar eclipses and recorded the solar ones. It is interesting to note that the history gave the dates of the solar eclipses always with their positions in the sky. When the total eclipse occurred, the history also gave the expressions as the day became dark as night, the stars appeared, and the birds and hens went back their nests, etc.

The earliest record of solar eclipse in China was found in Shu Ching, Book of Historical Documents, a Chinese classic. This eclipse was well known to the Chinese and Europeans, and has been fully discussed by a number of eminent authorities. The Punitive Expedition of Yin, the

*The author requested that his phraseology be changed so as to conform more nearly to accepted English usage. We have refrained from doing so, except in cases of obvious misspelling and omissions, in order that the personality of the writer might be preserved. As the meaning is clear, the value of the paper is in no way lessened by the style which is unconventional in places.—ED.

prince of Hsia, is the title of a chapter in Shu Ching, and recorded as follows: "In the first day of the last month of autumn the sun and the moon did not meet harmoniously in Fang. The blind beat their drums, the inferior officers galloped, and the common people ran about." The definite year was not given in the record, and the word Fang was sometimes used as the name of a lunar cycle, and sometimes as a small constellation including the stars β, δ, π, and ρ Scorpii. From this point of view there is some ambiguity. The Buddhist priest named I-Hang, a famous astronomer of the Tang Dynasty about 720 A.D., computed the date at the 5th year Ping Yin of Chung Kang (2155 B.C.). Kuo Shou Ching, the astronomer of the Yuan Dynasty about 1276 A.D., fixed the same date at the 5th year of Chung Kang, but the year cycle was Koei Se (2128 B.C.), which was 27 years behind Ping Yin as referred to by I-Hang. Chung Kang reigned only 13 years. Before the reform period of the Chou Dynasty at 841 B.C. the chronology was in confusion and not accepted by the historians and astronomers. Moreover, for the above referred dates there were no eclipses which could be seen in China. Oppolzer fixed the date at October 22, 2137 B.C. which was 10 years earlier than that of Kuo Shou Ching, while Schligel and Kühnert calculated another date at May 7, 2165 B.C. which was 10 years earlier than that of I-Hang. Such a remote eclipse was practically falling into confusion.

The next ancient eclipse of the sun whose date can be accurately fixed was preceded by an eclipse of the moon. In Shih Ching, as referred to above, there was a record which stated as follows: "The conjunction in the tenth month, the new moon on the first day Sing Mao, the sun was eclipsed, it was very bad." The record also mentioned the eclipse of the moon as quoted above. Dr. Mitchell determined the exact date and explained clearly: "The eclipse of the sun referred to took place on September 6, 776 B.C., the eclipse of the moon on August 21. The solar eclipse was visible only as a partial eclipse in China while that of the moon was nine-tenths." The eclipse of the sun could be seen in Lo-Yang, the capital of Chou, about two-tenths. It is interesting to note that the period from this eclipse to that of October 11, 668 B.C., over 108 years, 39512 days, is just twice of three Saroses. The evidence of the first reliable date of the solar eclipse in the Chinese history stands more firmly without doubt.

The Chun Chiu, or Spring and Autumn, written by Confucius, is best known as the Annals of Lu, his native state. The chief events that took place in the state are briefly summarized in the period of 242 year, 722 to 481 B.C. In the Annals there were 37 eclipses of the sun, 33 of which have been identified with certainty. Two eclipses of September 19, 552 B.C. and July 18, 549 B.C. were in error and did not take place, and two of them on February 4, 645 B.C. and April 9, 518 B.C. were not visible in China.

At the end of the Chou Dynasty the feudal states in Chinese empire were separated and attacked each other. After Chun Chiu there were

seven big states in feudal times from B.C. 460 to 220, which disturbed the peace of the country. The old calendars were said to have been lost, and the astronomical observations have not been properly recorded, or there were even no observations to be taken at all. When the Chou Dynasty was ruined in 255 B.C. Shih Huang Ti, the first emperor of Tsin Dynasty, conquered the whole empire and reigned a short time from B.C. 246 to 210. During the period from B.C. 460 to 210 about 250 years there were only nine eclipses of the sun recorded in the history and the most of them were written without the months and days. According to Oppolzer the one on April 20, 443 B.C. was a partial eclipse and that on August 5, 301 B.C. could be seen in China not more than three-tenths, while the history described these two eclipses in "the dark daylight." This expression was often used for a total eclipse in the Chinese history. These records must be in error, and the eclipse on March 14, 247 B.C. was also in error that could not be visible in China.

The historical eclipse of the sun in Shu Ching told us that the emperor Chung Kang ordered the prince Yin to execute the astronomers Hi and Ho who failed to predict the solar eclipse. This unfortunate story also told us that the ancient Chinese astronomers were in the duty of predicting eclipses more than 4,000 years ago. But up to the time of the Han Dynasty (204 B.C.) forty-eight solar eclipses were mentioned above, the method how to predict the eclipse of the sun could not find any clue in the history. Even in the Han Dynasty from 204 B.C. to 220 A.D. with a long period of 425 years, 141 eclipses of the sun were recorded in the Annals of Han, the calendars which have been used then showed how to calculate the eclipse of the moon but not of the sun. Therefore the solar eclipses described in the Annals of Han were actually seen, only two out of 141 eclipses were in error and did not occur in the time. This is perhaps the mistake in writing or printing as so far the history was carried down about two thousand years ago. There is an important fact that the solar eclipses in the Annals of Han did not always take place on the first day of the calendar month. It was usually one day before, or sometimes one day after which was due to the fact that the new moon did not fall exactly into the first day of the calendar month, because the calendars of Han used the mean new moon and did not apply the apparent new moon to match the first day of the month.

The empire of Han was divided by three states from A.D. 222 to 265. The leading one was Shuh, which had its capital at Chengtu, and comprised all the region west of Hupeh; the next was Wei, whose king Tsao Pi ruled at Loh-yang and swayed most of the region north of the Yangtze River; the third was Wu whose king Sun Küen was invested by the preceding at Nanking, and ruled all the eastern provinces. Each state had its own calendars which sometimes might have one day difference. The eclipses of the sun were recorded in the Annals of Wei in the History of Three States. They were twenty in number. It is interesting to note that in the state of Wei an astronomer Yang Wai established a calendar called Chin Ch'u about A.D. 237, and gave a method

to determine the direction angles at the first contact of the solar eclipse. This was supposed to be the first method to predict the eclipse of he sun.

Tu Yu, a historian of classic research in the Tsiu Dynasty about 280 A.D., determined the solar eclipses of Chun Chiu, the Annals of Lu, by ten calendars, and worked out the data to compare discriminatingly. In the Annals of Tsin there were 83 eclipses of the sun, of which 20 were already recorded in the Annals of Wei as referred to above. The sixty-three solar eclipses properly belonged to the Tsin Dynasty from A.D. 266 to 419. Three of them could not be identified with certainty which must be in error.

At the end of Tsin Dynasty China was divided into two empires, the North and the South. The North empire was ruled the region of Yellow River and reigned by two successive dynasties, namely the North Wei (A.D. 386 to 556) and the North Chou (557 to 581). The South empire was ruled along the Yangtze Valley and reigned by successive four dynasties, namely, the Sung (420 to 478), the Zu (479 to 502), the Liang (503 to 556), and the Cheng (557 to 589). The Huai River which ran west of Honan to north of Kiangsu was taken for their boundary line. The history is very difficult and easy to lead to a confusion. The Annals of the North and the Annals of the South were written by the same author, Li Yei Seu. The former recorded 79 eclipses of the sun and the latter only 36. Twenty-seven of them can be identified with the same year but they may not on the same day. Each dynasty also had its own annals which were comparatively more complicated.

When the Siu Dynasty conquered the whole empire, China was then united into one again at 590 A.D. The Annals of Siu recorded the solar eclipses from 420 to 618 A.D. including those of the South dynasties, but not in full. Ma Tuan Ling, a historian of the 13th century, collected 87 solar eclipses during that time. I have carefully examined all the Annals of these dynasties and found 109 eclipses of the sun from 386 to 618 A.D. so Ma Tuan Ling's collection is also not complete. Since the prediction of the solar eclipses had been improved in the Tsin Dynasty, the Huang Chi Calendar of Siu (604 A.D.) gave the methods for finding the first and the last contacts, and the position and the phases of the eclipses. Most of them recorded in the Annals must be predicted then, so there was about one third could not be seen in China.

The astronomers of the Tang Dynasty as Fu Chen Chin, Li Chen Fung and I-Hang calculated their new calendars which were successively adopted by the emperors. I-Hang's calendar was known as the best. From this epoch each emperor practically changed his new calendar, the astronomical observations were much improved then. The eclipses of the sun observed and recorded were 103 in number in the Tang Dynasty from A.D. 619 to 906. The Five Dynasties followed with a short period from A.D. 907 to 960 and twenty-six eclipses of the sun were recorded in the Annals of the period.

In the Sung Dynasty (961 to 1263 A.D.) the prediction and observa-

tion of the solar eclipses had been considered more important as the first duty for the astronomers. The Bureau of History was then established and had its duty to predict the eclipse and to keep the records. The Bureau of Astronomy was established at the same time and had its duty to observe the eclipse and to record the phenomena. If their work be found in error, the officers should be punished with depressing their ranks, or stopping the payments of their salaries. There were 152 solar eclipses during 300 years in the Sung Dynasty. Every one was on the first day of the calendar month. This proves that the Sung calendars have been improved, and also that the beginning and ending of the eclipses were clearly indicated.

Kuo Shuh Ching, the well-known astronomer of the Yuan Dynasty about 1281, made a calendar with actual observations, and overthrew the old method which was supposed to be the sun, the moon, and the five planets in conjunction on the same day as the beginning of the calendar. He showed his calendar as a practical one and explained a method of predicting eclipses. He also calculated back the ancient eclipses, two from Shu Ching and Shih Ching, thirty-six from Chun Chiu, and thirty-five from the other history. There were sixty-one eclipses of the sun recorded in the Annals of Yuan in 104 years from A.D. 1264 to 1368.

When the Yuan Dynasty fell in 1369 the new dynasty Ming had to change the calendar. The new calendar was called Da Tung and revised in 1384. In fact this calendar was copied from the method of Kuo Shuh Ching and omitted his important part of annular acceleration, whence the predicted time of solar eclipses did not accord with the actual observations, usually three of four hours were in difference. The astronomers noticed the mistakes in the calendar, but it could not be changed without the order of the Emperor. In 1554 Tsu Tsai Yuo, the Prince Tching, made a new calendar, and in 1581 he revised it again. By his methods he calculated back 25 eclipses of the sun mentioned in the Annals and showed that the Da Tung calendar was in error. Unfortunately his calendars were not accepted by the Emperor. In 1583 P. Mathieu Ricci, an Italian missionary, introduced the European methods. In 1628 P. Adam Schall proposed a new calendar which was put in use until the fall of the Dynasty. There were 145 solar eclipses in the Annals of Ming, about 50 of them could not be seen in China.

At the opening of the Tsing Dynasty Schall became an imperial astronomer and the calendar was then adopted. In 1645 P. Ferdinal Verbiest revised this calendar and made some improvements. Fifty-two solar eclipses recorded with every detail in the first 150 years of the Tsing Dynasty from 1645 to 1795. It is to be regretted that the records in the 19th century are said to have been lost at the overthrow of the Dynasty in 1911. The following table is a summary from the Chinese history that shows the distribution of the solar eclipses.

Period	P.	T.	A.	A.T.	Error	Sum
Shu Ching (?)	0	1	0	0	0	1
Shih Ching (B.C. 776)	0	0	0	1	0	1
Chun Chiu (B.C. 722-481)	2	18	15	0	2	37
Feudal States (B.C. 480-205)	4	3	2	0	0	9
Han (B.C. 204-A.D. 219)	23	56	46	14	2	141
Three States & Tsin (A.D. 220-419)	20	31	26	3	3	83
North & South Reigns (420-618)	20	41	46	2	0	109
Tang & Five Dynasties (619-960)	20	48	57	4	0	129
Sung (961-1263)	26	53	66	7	0	152
Yuan (1264-1368)	12	21	20	8	0	61
Ming (1369-1644)	41	44	46	14	0	145
Tsing (1645-1795)	6	19	19	8	0	52
Sum	174	335	343	61	7	920

According to Oppolzer there are 8000 solar eclipses in 3368 years, taking the average there are 237.5 eclipses in a century. Of them 83.3 are partial, 77.5 annular, 10.5 annular and total, and 65.9 total eclipses. In the above table the partial eclipses are less frequent than total. This is due to the fact that the eclipses missed in the Chinese records must be the partial, which can be seen in a limiting place and are very easy to be overlooked. Moreover the Chinese old astronomer considers the solar eclipse less than three-tenths as the eclipse of no harm and does not care of very much. This is another fact why the partial eclipses are lost in the records more than total.

66 YEN CHIA HANG, SOOCHOW, CHINA.

Planet Notes for April, 1934

By CLIFFORD E. SMITH

The *Sun* will be moving northeast from the central part of Pisces to the central part of Aries. Its position on the first and last days of the month will be, respectively: R.A. $0^h\ 39^m$, Decl. $+4°\ 11'$; and R.A. $2^h\ 26^m$, Decl. $+14°\ 29'$.

The phenomena of the *Moon* will occur as follows:

Last Quarter	April	6 at	7 P.M.	C.S.T.
New Moon		13 "	6 P.M.	"
First Quarter		21 "	3 P.M.	"
Full Moon		29 "	7 A.M.	"
Perigee		7 "	5 A.M.	"
Apogee		20 "	8 P.M.	"

Mercury will be moving from the central part of Aquarius to the eastern part of Pisces. During this period it will be on the meridian about an hour before the sun. Thus it will be a morning star. On April 2 at 5:00 A.M., C.S.T., Mercury will be at greatest elongation west (27° 49′). On April 11 at $9^h\ 40^m$ P.M., C.S.T., Mercury will be in conjunction with the moon (Mercury 6°.4 S). The distance of Mercury from the earth will be increasing from about 80 million to about 117 million miles, and its apparent diameter will be decreasing from about 8 to about 5½ seconds of arc. The position of Mercury on the first and last days of the month will be, respectively: R.A. $22^h\ 29^m$, Decl. $-8°\ 6'$; R.A. $1^h\ 34^m$, Decl. $+7°\ 48'$.

Venus will be moving from the western to the eastern part of the constellation Aquarius. It will be a morning star, and it will be on the meridian about three

hours before the sun. Its distance from the earth will be increasing from about 50 to about 75 million miles, and its apparent diameter will decrease from about 30 to about 21 seconds of arc. On April 1 at 9:00 A.M., C.S.T., Venus will be in conjunction with Saturn (Venus 3°.5 N). On April 10 at $3^h\ 22^m$ P.M., C.S.T., Venus will be in conjunction with the moon (Venus 20′ S).

Mars will be near the sun in apparent position during this period. Conjunction with the sun will occur on April 14 at 8:00 A.M., C.S.T.

Jupiter will be above the horizon most of the night hours since it will be in central Virgo. Opposition with respect to the sun will occur on April 8 at 3:00 P.M., C.S.T. Its apparent diameter will be about 41 seconds of arc, and its distance from the earth will be about 400 million miles. An April 27 at $7^h\ 53^m$ P.M., C.S.T., Jupiter will be in conjunction with the moon (Jupiter 6°.5 N).

Saturn will be a morning object in eastern Capricornus. During the middle of the month it will be on the meridian about 8:00 A.M., Standard Time. As has been mentioned under the notes on Venus, Saturn will be in conjunction with Venus on April 1. On April 9 at $2^h\ 10^m$ P.M., C.S.T., Saturn will be in conjunction with the moon (Saturn 2°.0 S). Its distance from the earth will be about 960 million miles, and its apparent diameter will be about 14 seconds of arc.

Uranus will be too near the sun to be of interest during this period. Conjunction with the sun will occur on April 17 at 9:00 P.M., C.S.T.

Neptune will be in Leo about two degrees in a northwesterly direction from χ Leonis. Its distance from the earth will be about 2740 million miles, and its apparent diameter will be about 2½ seconds of arc. It will be well above the horizon during the first half of the night since it will be on the meridian about $9^h\ 30^m$ P.M., Standard Time, during the middle of the month. Conjunction with the moon will occur on April 24 at $10^h\ 47^m$ P.M., C.S.T. (Neptune 3°.3 N). The position of Neptune on April 13 will be R.A. $10^h\ 47^m$, Decl. +8° 41′.

OCCULTATION PREDICTIONS

(Taken from the *American Ephemeris.*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

Date 1934	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
April 21	187 B.Gem	6.3	4 8.3	−0.9	−0.3	52	4 37.8	+1.1	−2.8	351
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′.										
April 1	75 Vir	5.6	5 30.8	−2.0	+0.4	98	6 40.2	−1.0	−1.4	333
6	φ Sgr	3.3	12 21.9	−1.6	+0.3	60	13 38.4	−1.8	−0.8	269
21	187 B.Gem	6.3	3 55.7	−0.8	−1.3	90	4 55.0	+0.2	−2.2	318

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.

April	1	75	Vir	5.6	5	7.0	0.0	−1.3	161	6	1.4	−1.6	+1.1	268
	6	ϕ	Sgr	3.3	11	22.2	−1.9	+1.5	62	12	38.1	−2.0	+0.1	286
	6	σ	Sgr	2.1	17	6.5	0.0	+0.8	27	17	55.2	−1.4	−2.0	292
	9	44	Cap	6.0	12	36.0	−1.1	+0.8	109	13	24.6	−1.0	+2.6	198
	20	37	Gem	5.7	6	54.4	..	..	31	7	7.9	..	..	5
	21	187	B.Gem	6.3	3	37.1	−1.8	−2.9	148	4	46.4	−1.8	−1.1	266

Comet Notes

By G. VAN BIESBROECK

No great activity is displayed in the comet world these days. No known comets are in reach of ordinary instruments although several faint ones are followed with larger telescopes.

COMET 1933 *f* (WHIPPLE) which was discovered most recently is now becoming a very faint object in the evening sky. Plates taken by the writer in the middle of February show that it is reduced to a small coma not brighther than a star of magnitude 16 and that, as foreseen, it gradually fades away. It may be followed in the constellation of Taurus for perhaps another month but after that it will be lost in the light of the sun. The following ephemeris is deduced from the elements by A. D. Maxwell and H. M. Porter given on p. 86:

1934 0^h U.T.	α h m s	δ ° ′	—Distance from— Earth	Sun	Mag.
Feb. 28	3 38 28	+10 4.1	2.88	2.82	16.2
Mar. 8	48 13	10 49.2			
16	58 32	11 32.9	3.13	2.86	16.4
24	4 9 21	12 14.3			
April 1	20 34	+12 52.9	3.36	2.91	16.6

The magnitudes are added on the assumption that February 12 corresponded to magnitude 16.0.

COMET 1932 *g* (GEDDES) is now well placed for observation, slowly describing a loop in Ursa Major, where it will remain for several months. I have computed the continuation of the ephemeris from the elements by J. Bobone (Harvard Announcement Card 236):

1934 0^h U.T.	α h m s	δ ° ′	—Distance from— Earth	Sun	Mag.
Feb. 28	13 10 25	+60 39	5.17	5.74	15.1
Mar. 8	12 58 49	62 6	5.25	5.80	15.2
16	12 45 40	63 18	5.34	5.87	15.2
24	12 31 33	64 11	5.44	5.93	15.3
April 1	12 17 6	64 47	5.56	5.99	15.4
9	12 2 58	65 5	5.69	6.05	15.5
17	11 49 48	65 9	5.83	6.12	15.5
25	11 38 4	64 59	5.97	6.18	15.6
May 3	11 28 4	+64 38	6.12	6.24	15.7

The magnitude was taken as 15^M on February 12 to correspond to the estimations by the writer.

COMET 1925 II (PERIODIC SCHWASSMANN-WACHMANN) has now been observed again. From W. Baade at Mount Wilson came word that he had observed this curious object on January 13 as a minute diffuse disc of 1″.6 diameter, without any halo. This observation was made photographically with the 100-inch re-

flector and the brightness was estimated as $18^{M}.5$, which is as faint as any comet has ever been observed. Since then the comet has been recorded on plates taken by the writer with the 24-inch reflector on February 15 and February 19, the brightness being estimated at $17^{M}.5$; the appearance seemed to have changed since last month: there now was a very diffuse coma some 12″ in diameter, without any indication of a central disc. It will be of interest to follow the further developments at this opposition, remembering that in the past this object has sometimes gained several magnitudes in a couple of days with large modifications in its angular size and condensation. The ephemeris by J. G. Behrens is continued here from p. 50:

1934 0^{h} U.T.	α h m	δ ° ′
Feb. 28	10 16.8	+8 13
Mar. 8	13.6	26
16	10.6	40
24	8.0	8 52
April 1	5.7	9 2
9	3.8	10
17	2.6	16
25	1.8	18
May 3	1.6	18
11	2.0	15
19	2.9	9
27	4.3	9 0
June 4	6.3	8 49
12	10 8.7	+8 35

According to Baade the correction of the ephemeris is only $0^{m}1$ in α, 0 in δ. The path is in Leo some 3 or 4 degrees southeast of Regulus.

No information has been received so far concerning the expected Periodic Comet Tuttle-Giacobini for which a search ephemeris was given on p. 51.

Williams Bay, Wisconsin, February 20, 1934.

Variable Stars

Monthly Report of the American Association of Variable Star Observers for January, 1934

Again the severity of the winter weather all over the northern hemisphere has had its effect on the length of reports communicated during January. Nevertheless more than 2000 observations were reported from 46 observers. We welcome an initial report from Mr. Robert Miller of Miami, Florida, and Mr. George Skora of Tucson, Arizona.

Mira, o Ceti, has apparently reached maximum magnitude 3.8. The rise was somewhat less rapid than the previous one, fifty days being required to increase four magnitudes, as against thirty days in 1933. Chi Cygni experienced a marked still stand on the rise to maximum between magnitudes 8.0 and 7.0, and attained the fifth magnitude. This star undergoes the greatest change in brightness of all the long-period variables, approximately nine magnitudes in a period of tihrteen and one-half months.

SU Tauri, R Coronae Borealis, and RY Sagittarii require the closest of attention in order that marked changes in brightness may not escape detection. U Geminorum has just passed through a maximum, the first observed since March, 1933.

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1934.

Nov. 0 = J.D. 2427377; Dec. 0 = J.D. 2427407; Jan. 0 = J.D. 2427438.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V Scl	S Tuc	W Cas	R Scl	R Ari	o Cet
000339	*001862*	004958	*012233a*	021024	*021403*
386 12.9 En	386[13.5 Sl	391 11.9 My	367 8.5 Kd	419 11.5 Jo	442 5.2 Ra
S Scl	S Cet	398 12.0 My	394 8.6 Kd	423 11.0 Jo	443 5.1 Bd
001032	*001909*	414 12.2 My	399 8.5 Kd	440 9.4 Hf	443 6.0 Mi
367 6.7 Kd	391 13.5 L	419 11.5 Jo	RZ Per	447 8.9 Hf	444 5.9 Mi
369 6.7 Kd	426[12.3 Pt	420 11.6 Fd	012350	447 8.8 Wd	445 5.0 Bd
386 7.3 En	T Scl	423 11.3 Jo	384 9.0 L	449 9.4 So	445 5.2 Ra
391 7.2 Kd	*002438a*	427 11.9 My	422 10.1 B	W And	446 5.1 Hf
394 7.4 Kd	386 9.8 En	427 12.1 Pt	R Psc	021143a	446 5.7 Mi
399 7.4 Kd	W Scl	428 11.1 B	012502	445 11.6 Mi	446 5.1 Wd
X And	*002833*	437 11.1 B	347 8.9 Bm	447 11.3 Pt	447 5.2 Wd
001046	386 12.8 En	441 11.0 Ra	369 9.2 Bm	T Per	447 4.8 Bd
347 13.0 Bm	U Cas	447 11.2 Wd	378 9.6 Bm	021258	447 5.1 Hf
356 13.6 Bm	004047a	448 11.5 My	383 9.9 Bm	392 9.4 Lt	447 5.0 Ra
369 14.4 Bm	384 13.7 L	449 11.2 Wd	404 10.4 Bm	417 8.5 Pk	448 5.2 Hf
383 14.7 Bm	422 11.2 Pf	449 11.2 Hf	RU And	417 9.5 Lt	448 4.5 Sf
440 14.0 GC	423 11.3 Jo	449 11.4 So	013238	419 8.5 Jo	448 5.2 Wd
443 13.5 B	426 11.0 Wh	452 10.8 Fd	391 13.2 L	423 8.5 Jo	449 5.1 Wd
449 13.3 GC	426 10.7 Pt	U Tuc	447 12.5 Pt	425 8.9 Hf	449 5.0 Hf
T Cet	428 10.7 B	*005475*	449 11.3 So	440 9.0 Hf	S Per
001620	437 9.7 B	386 13.7 En	Y And	444 9.0 Ra	021558
367 6.6 Kd	440 10.0 Wa	386 13.5 Sl	013338	446 9.3 Sx	413 9.3 My
373 6.5 Kd	443 9.4 Wh	397 13.4 Sl	384 11.5 L	447 9.1 Pt	417 9.3 Pk
391 5.7 L	444 9.9 Ra	Z Cet	419 9.7 Cy	447 9.1 Wd	419 9.0 Jo
392 5.9 Lt	446 9.8 Hf	*010102*	429 9.9 Cy	Z Cep	419 9.2 Cy
393 6.6 Kd	448 9.5 Sf	391 10.8 L	447 10.2 Pt	021281	423 9.1 Jo
398 6.5 Kd	RW And	412 9.8 Wh	448 11.4 Sf	384 11.3 L	424 9.3 Pk
405 5.9 Lt	004132	414 9.3 Jo	449 10.7 So	o Cet	425 10.3 Hf
417 5.8 Lt	449 12.0 So	421 8.9 Jo	X Cas	*021403*	427 9.6 My
426 6.2 Lt	V And	435 9.1 Ko	014958	386 8.9 En	429 9.4 Cy
T And	004435	443 9.3 Wh	416 11.8 Bn	391 8.8 L	440 9.7 Hf
001726	347 11.4 Bm	447 9.1 Pt	421 11.8 Bn	391 9.0 Me	444 10.2 Ra
441 11.0 So	369 12.8 Bm	U And	437 10.0 B	407 8.2 Jo	446 9.8 Sx
449 11.6 So	383 13.6 Bm	010940	447 11.6 Pt	414 7.8 Jo	447 10.1 Wd
T Cas	391 13.5 L	384 10.4 L	449 11.0 So	415 7.8 Ah	447 9.5 Pt
001755	449 14.6 GC	441 10.8 So	452 10.7 Fd	415 8.0 Mi	447 9.8 Ra
384 11.6 L	X Scl	449 11.3 So	U Per	416 7.9 Mi	448 9.8 My
417 12.2 My	*004435*	UZ And	015254	417 7.8 Oy	449 10.0 So
419 12.0 Jo	386[13.0 En	011041	411 10.3 Ry	419 7.6 Je	R Cet
419 11.6 Mi	RR And	449[13.6 So	413 10.7 My	419 7.6 Cy	*022000*
419 11.9 B	004533	S Cas	417 10.8 Ry	419 7.8 Mi	384 9.8 L
420 11.6 Mi	347 9.0 Bm	011272	419 10.9 Cy	420 7.6 Mi	391 10.3 My
421 11.6 Mi	369 10.0 Bm	391 10.0 My	425 10.4 Hf	421 7.5 Mi	398 10.7 My
423 12.2 Jo	376 10.0 Bm	398 10.1 My	427 11.0 My	421 7.0 Jo	427 12.5 My
425 11.8 Mi	381 10.9 Bm	417 11.2 My	429 11.7 Cy	422 7.8 Ra	449 12.5 Hf
426 12.2 Pt	404 11.5 Bm	417 10.5 Jo	447 11.4 Pt	423 7.3 Mi	451 12.6 My
427 12.2 My	449 12.9 So	419 11.5 Mi	448 11.5 My	423 7.6 Bd	RR Per
432 12.0 B	RV Cas	420 11.5 Mi	449 11.6 So	426 7.0 Jo	022150
442 11.9 Mi	004746a	421 11.4 Mi	449 11.6 Hf	426 7.2 Sx	391 11.7 L
442 12.3 Ra	422 10.0 Pf	421 10.7 Jo	449 11.7 Wd	427 7.1 Je	425 10.5 Hf
444 11.9 Mi	426 10.9 Pt	427 11.7 My	452 11.7 Fd	429 6.4 Je	U Cet
447 12.0 Wd	428 10.5 B	437 11.1 B	S Ari	429 6.7 Oy	*022813*
448 12.0 My	437 10.7 B	447 11.5 Pt	015912	429 6.6 Cy	392 7.1 Lt
449 12.1 So	448 11.6 Sf	448 11.8 My	384 12.6 L	434 6.3 Rb	407 7.1 Jo
R And	— Cas	449 9.8 Wh	449[13.8 GC	440 5.6 Hf	414 7.5 Jo
001838	004746b	U Psc	R Ari	440 5.7 Bd	417 7.9 Lt
426[12.4 Pt	422 10.8 Pf	011712	021024	440 5.5 Sx	419 8.1 Cy
444 11.6 Ra	426 11.0 Pt	447[12.3 Pt	391 12.8 L	442 6.2 Mi	421 7.8 Jo

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1934.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
U CET			**R HOR**			**T TAU**			**R RET**			**V ORI**			**S AUR**		
022813			*025050*			041619			*043263*			050003			052034		
421	7.6	B	386	9.6	En	369	10.7	Bm	386	12.6	Sl	347	9.2	Bm	448	9.2	My
422	8.3	Ra	386	8.8	Sl	378	10.3	Bm	X CAM			358	9.8	Bm	448	9.8	Mc
426	8.0	Jo	**T HOR**			384	10.5	Bm	043274			369	10.1	Bm	449	10.5	So
426	8.5	Lt	*025751*			402	10.5	Bm	384	9.0	L	378	10.7	Bm	**W AUR**		
426	8.5	Sx	386	8.3	En	**R TAU**			393	8.2	My	384	11.2	Bm	052036		
445	9.5	Sx	386	7.9	Sl	042209			407	7.8	Jo	384	11.1	L	391	14.0	L
445	9.7	Mi	**U ARI**			347	13.2	Bm	413	8.0	Jo	402	12.5	Bm	421	[13.3	B
447	8.4	Pt	030514			358	13.9	Bm	414	8.2	My	420	13.5	B	429	[13.2	Wd
R TRI			347	11.0	Bm	369	14.0	Bm	419	8.4	Cy	446	[12.3	Pt	446	[12.0	Pt
023133			358	11.5	Bm	378	13.7	Bm	421	8.0	Jo	**T LEP**			449	14.0	GC
396	9.2	SR	369	11.6	Bm	402	13.7	Bm	427	8.1	My	*050022*			**S ORI**		
411	9.5	SR	378	11.8	Bm	422	12.3	B	429	8.8	Cy	347	12.6	Bm	*052404*		
412	9.3	Ah	383	11.2	Bm	432	12.5	B	448	10.4	My	358	12.4	Bm	413	8.8	Jo
413	9.5	SR	391	12.8	L	447	12.5	Wd	451	10.6	My	369	12.0	Bm	419	8.8	Jo
415	9.4	Ah	404	12.6	Bm	**W TAU**			**R DOR**			378	11.6	Bm	421	9.2	B
419	9.3	Jo	**X CET**			042215			*043562*			384	11.6	Bm	422	9.3	Ra
423	9.5	Jo	*031401*			384	10.9	L	383	5.5	En	402	12.8	Bm	423	8.8	Jo
423	9.6	Bd	384	8.8	L	413	10.4	Jo	385	5.6	Sl	423	9.6	Jo	424	8.9	Wh
426	9.8	Sx	407	8.8	Jo	414	10.1	My	**R CAE**			444	9.3	B	442	10.1	Sx
442	10.3	Ra	413	9.3	My	415	9.8	B	*043738*			445	10.2	Mi	444	10.0	Mi
445	10.8	Mi	414	9.4	Jo	419	10.0	Cy	402	8.1	En	446	10.5	Pt	444	9.5	B
445	10.4	Sx	421	10.0	Jo	421	10.1	Jo	**V TAU**			449	9.4	Hf	446	9.3	Pt
445	10.3	Bd	422	10 2	Ra	422	9.6	B	044617			449	9.3	Wd	449	10.2	So
447	11.0	Wd	423	9.8	B	427	9.8	My	421	11.9	B	450	10.0	Me	450	10.2	Me
447	10.0	Pt	423	9.5	Sx	429	10.1	Cy	446	11.0	Pt	**R AUR**			**T ORI**		
449	11.2	Sf	426	10.5	Jo	432	9.3	B	450	9.6	Me	050953			*053005a*		
T ARI			427	9.7	My	446	10.1	Pt	**R ORI**			425	12.4	Ar	384	10.0	L
024217			445	10.7	Sx	448	9.4	My	045307			427	12.2	Ar	391	9.9	L
413	9.6	Jo	445	11.4	Mi	449	10.2	So	384	9.7	L	428	12.2	Ar	391	9.9	Me
421	9.5	Jo	448	11.5	My	450	9.8	Me	419	9.5	Cy	431	12.1	Ar	392	9.7	Me
423	9.6	Bd	451	11.6	My	452	9.8	Fd	423	9.3	B	433	12.1	Ar	413	10.5	Jo
426	9.4	Jo	**Y PER**			**S TAU**			429	9.6	Cy	442	11.2	Bd	413	10.5	My
440	9.2	Bd	032043			042309			432	9.5	B	445	10.9	Bd	414	10.8	My
443	9.4	Bd	414	9.9	My	347	11.6	Bm	449	10.0	Sf	446	11.2	Pt	415	10.7	SR
443	9.0	Me	417	9.6	Pk	358	12.0	Bm	450	9.7	Me	447	10.9	Bd	416	11.0	Me
446	9.3	Bd	417	9.7	Sq	361	12.7	Cy	**R LEP**			**S AUR**			418	10.9	SR
450	9.1	Me	423	10.6	Jo	369	12.8	Bm	*045514*			052034			419	10.7	Cy
W PER			424	9.7	Pk	371	12.4	Cy	384	7.6	L	371	10.0	Ho	419	10.7	My
024356			425	10.4	Hf	378	12.8	Bm	386	7.5	Sl	412	9.0	Pk	419	10.6	Jo
411	9.1	Ry	442	9.8	Wh	384	13.2	Bm	407	7.8	Jo	413	9.8	Jo	421	11.0	SR
413	8.7	My	444	10.6	Ra	402	14.0	Bm	414	8.0	Jo	414	9.9	My	422	10.8	Ra
417	9.0	Ry	446	10.2	Pt	447	[13.5	Wd	417	9.5	Oy	416	9.6	B	423	10.4	Jo
419	9.1	Cy	451	10.4	My	**T CAM**			419	10.0	Je	418	10.0	B	423	10.7	Pt
421	8.6	Jo	**R PER**			043065			422	9.7	Ra	419	9.7	Jo	424	10.5	Pt
423	9.4	Sx	032335			384	8.1	L	423	8.5	Jo	420	9.7	B	425	10.2	Ar
426	9.0	Jo	391	14.0	L	407	8.8	Jo	425	9.6	Hf	422	10.5	Ra	426	10.5	Jo
427	8.9	My	414	12.3	My	413	9.0	Jo	427	9.5	Je	423	8.9	Pk	426	10.8	Pt
429	9.4	Cy	422	12.3	B	421	9.7	Jo	429	9.5	Je	426	9.2	Pk	426	10.9	SR
440	9.2	Hf	446	12.1	Pt	425	9.6	Hf	429	8.2	Ko	426	9.6	Jo	427	11.3	Ar
442	8.8	Wh	448	10.5	Hf	426	10.2	Jo	429	9.7	Oy	429	10.0	Ko	427	10.9	My
442	9.0	Ra	451	10.2	My	446	9.5	Pt	440	9.6	Hf	429	10.0	Wd	427	10.8	Pt
445	9.5	Sx	**NOV PER**			447	10.1	Hf	442	9.7	Sx	429	10.1	Hf	428	10.6	Pt
446	9.2	Pt	032443			**RX TAU**			446	8.0	Pt	429	10.0	B	428	10.7	Ar
448	8.9	My	446	[12.6	Pt	043208			447	9.7	Hf	439	9.4	B	429	10.2	Ko
449	9.3	So	**T TAU**			391	13.8	L	**W ORI**			442	9.7	B	429	10.4	Wd
452	9.2	Fd	041619			421	13.0	B	050001			446	10.2	Hf	429	10.5	Hf
			347	10.4	Bm	450	12.4	Me	429	6.3	Oy	446	9.5	Pt	429	10.8	B
			358	10.4	Bm							447	9.9	Bd	429	10.6	Cy

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T ORI	RR TAU	SU TAU	U ORI	AG AUR	R LYN
053005a	053326	054319	054920a	062047	065355
431 10.6 Ar	384 11.2 Bm	443 9.9 B	440 6.4 Sx	384 10.3 L	429 9.1 B
433 10.4 Ar	384 11.2 L	444 10.5 Pt	440 6.7 Bd	U LYN	442 9.3 Ra
434 10.3 Ar	391 11.5 L	444 10.5 Me	442 6.7 Bd	063159	443 9.6 Bd
435 10.1 Cy	391 11.2 Me	444 10.4 SR	444 6.9 Wd	449 14.0 GC	446 9.3 Bd
437 10.1 B	392 11.2 Me	445 10.5 Pt	444 6.9 B	R MON	447 9.8 Hf
440 10.4 Pt	402 13.0 Bm	446 10.6 Pt	444 6.9 Mi	063308	RS GEM
442 9.4 SR	419 12.9 Cy	446 10.6 SR	445 6.8 Bd	423 11.4 Jo	065530
442 10.3 Sx	423 12.4 B	447 10.6 SR	446 6.8 Wd	NOV PIC	414 10.6 Jo
443 9.7 SR	428 12.0 Ko	447 10.4 Bd	446 7.1 Hf	*063462*	416 11.4 Me
443 10.4 Me	429 12.6 Cy	447 10.7 Wa	447 6.8 Bd	386 8.7 En	418 12.1 SR
444 10.1 Me	443 12.3 Me	448 10.6 Pt	448 7.0 Kg	392 8.7 En	419 12.1 SR
444 10.5 Pt	444 11.7 Me	449 10.9 Sf	448 7.0 Lr	402 8.8 En	421 12.1 SR
444 10.0 SR	447 12.0 Wa	449 10.9 SR	448 7.2 Mc	S LYN	423 11.3 Jo
445 10.4 Pt	449 11.5 GC	450 10.9 Me	452 7.1 Fd	063558	426 12.1 SR
446 10.5 Pt	450 12.1 Me	450 10.6 Pt	V CAM	391 13.1 L	427 12.1 SR
446 10.7 SR	RU AUR	Z TAU	054974	414 11.0 Jo	442 12.1 SR
446 10.6 Wd	053337	054615a	426[12.2 Pt	414 11.7 Ry	443 12.0 SR
447 10.0 SR	426[12.0 Pt	347 13.0 Bm	Z AUR	417 11.4 My	443 11.4 Me
447 10.3 Hf	449[13.4 GC	369 12.8 Bm	055353	419 10.8 Jo	444 12.2 Me
448 10.5 Hf	U AUR	378 13.2 Bm	407 9.5 Jo	423 10.8 Jo	444 12.0 SR
448 10.5 My	053531	384 13.4 Bm	414 10.3 Jo	429 10.6 B	446 12.1 SR
448 10.5 Pt	391 13.0 L	391 13.5 L	418 10.7 B	440 10.0 GC	447 12.1 SR
449 9.7 So	415 13.0 B	402 13.0 Bm	419 10.5 Jo	442 9.8 Ra	449 12.1 SR
449 10.3 Wd	421 13.2 B	449 14.0 GC	419 11.0 Cy	448 9.1 My	V CMI
449 10.3 Hf	SU TAU	RU TAU	420 10.6 B	449 9.5 Sf	070109
449 10.0 SR	054319	054615c	421 10.7 B	449 9.5 GC	391 9.0 L
450 10.6 Pt	384 9.8 L	369[14.7 Bm	421 10.8 Jo	X GEM	414 10.0 Jo
450 10.4 Me	391 9.6 L	384[13.5 Bm	423 11.0 Jo	064030	422 10.8 Ra
451 9.8 Wd	391 10.1 Me	449 14.2 GC	428 10.8 GC	414 8.2 Jo	423 11.1 Jo
451 9.9 My	392 9.9 Me	α ORI	428 10.7 B	419 8.3 Jo	425 11.0 Hf
451 9.8 Kg	404 9.8 Cy	054907	429 11.2 Cy	419 8.7 Cy	R GEM
AN ORI	415 9.6 B	417 0.5 Lt	439 11.0 B	429 9.0 Cy	070122a
053005t	416 9.5 SR	427 0.6 Lt	440 11.0 GC	429 8.6 B	407 7.0 Jo
422 11.4 Ra	417 9.9 Jo	U ORI	443 11.5 B	442 9.1 Ra	414 7.2 Jo
425 11.5 Ar	418 9.5 SR	054920a	447 11.2 Bd	446 9.0 Hf	415 7.0 Ah
429 11.6 Hf	418 9.5 B	407 6.5 Jo	449 11.2 GC	447 9.0 Wd	417 7.3 Jo
429 11.5 Wd	419 9.3 Cy	411 6.7 Ah	X AUR	448 9.4 Hf	418 7.1 Hf
431 11.9 Ar	419 9.4 SR	413 6.7 Jo	060450	Y MON	419 7.6 Je
433 12.0 Ar	420 9.6 Pt	414 6.8 Sq	384 8.9 L	065111	421 7.5 Jo
434 12.1 Ar	421 9.7 B	415 6.7 Ah	407 8.5 Jo	391 14.0 L	421 7.2 Ra
446 11.5 Wd	421 9.4 SR	417 6.8 Oy	414 9.1 Jo	442 12.2 Ra	425 7.0 Hf
449 11.6 Wd	423 9.6 Pt	418 7.3 Hf	422 9.5 B	X MON	427 7.3 Je
449 11.6 Hf	424 9.6 Pt	419 7.0 Je	423 9.8 Jo	*065208*	429 7.3 Je
451 11.8 Wd	426 9.6 Pt	420 6.5 Fd	426 10.1 Pt	384 8.7 L	434 7.0 Rb
S CAM	426 9.4 SR	422 6.2 Ra	432 10.6 B	414 8.8 Jo	434 7.1 Hf
053068	427 9.7 SR	423 6.6 B	442 10.0 Sx	422 8.8 Ra	440 7.0 Hf
408 9.0 Jo	427 9.7 Pt	423 6.7 Sx	442 11.7 Ra	423 8.4 Jo	442 6.8 Sx
414 9.6 My	428 9.7 Pt	423 6.6 Jo	V AUR	425 9.0 Hf	443 6.8 Me
421 8.8 Jo	428 9.8 Ko	423 7.0 Bd	061647	442 8.8 Sx	446 7.1 Wd
426 8.8 Jo	429 9.6 Pt	425 6.9 Hf	391 12.0 L	447 8.6 Hf	446 7.0 Hf
426 10.0 Pt	429 9.8 B	427 6.6 Je	422 12.0 B	R LYN	446 6.6 Sh
448 8.8 My	429 9.8 Cy	427 6.8 Sq	432 11.6 B	065355	446 7.0 Pt
RR TAU	435 9.3 Cy	429 6.6 Je	V MON	391 7.7 L	450 6.6 Sh
053326	439 9.8 B	429 6.5 Oy	*061702*	412 8.7 Ah	Z GEM
347 11.6 Bm	440 10.3 Pt	429 6.7 Wd	426[12.5 Pt	414 8.5 Jo	070122b
358 11.8 Bm	442 10.9 SR	429 6.8 Hf		419 9.0 Je	446 12.3 Pt
369 11.7 Bm	443 10.6 SR	434 6.8 Hf		427 9.0 Je	447 12.4 Wd
378 12.3 Bm	443 10.5 Me	440 6.9 Hf		429 9.0 Je	

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
TW GEM	S GEM	T HYA	R LEO	SS VIR	U UMI
070122c	073723	*085008*	094211	122001	141567
422 8.5 Ra	446 10.1 Pt	391 12.2 L	444 6.7 Mi	426 8.6 Jo	408 8.8 Jo
425 8.4 Hf	448 10.0 Hf	419 10.5 Cy	444 7.0 Ra	428 8.9 Ko	411 9.3 Ah
440 8.5 Hf	449 10.1 Hf	429 9.9 Cy	446 6.0 Pt	T CVN	414 9.0 Jo
442 8.5 Sx	449 10.4 Wd	449 9.0 GC	447 7.0 Wd	122532	415 9.3 Ah
446 8.4 Wd	450 9.4 Sh	T CNC	448 6.9 Hf	419 10.0 Cy	419 9.4 Cy
446 8.4 Hf	T GEM	085120	451 8.5 Mc	423 10.0 Jo	421 9.0 Jo
446 8.1 Pt	074323	407 8.6 Jo	452 7.0 Fd	426 9.7 Jo	426 9.0 Jo
R CMI	414 8.7 Jo	414 8.5 Jo	V LEO	429 9.9 Cy	429 9.5 Cy
070310	419 8.4 Jo	419 9.8 Cy	095421	Y VIR	S Boo
391 10.6 L	419 9.1 Cv	423 8.5 Jo	419 10.5 Cy	*122803*	141954
414 9.7 Jo	423 8.4 Jo	429 10.2 Cy	429 10.5 Cy	402 11.4 Bm	423 10.7 Jo
422 9.5 Ra	429 8.6 Cy	446 9.1 Pt	S CAR	T UMA	429 11.1 Pt
423 9.5 Jo	U PUP	S PYX	*100661*	123160	V Boo
425 10.0 Hf	*075612*	*090024*	386 8.6 Sl	411 7.9 Ah	142539a
429 9.8 Oy	449 13.0 GC	378 12.6 Bm	R UMA	414 7.9 Jo	419 9.0 Cy
444 9.1 Mi	R CNC	428[12.4 Ko	103769	415 8.0 Ah	423 9.3 Jo
447 9.4 Hf	081112	V UMA	412 9.8 Ah	422 7.8 Ra	429 9.2 Cv
L2 PUP	419 10.9 Cy	090151	415 9.3 Ah	423 7.9 Jo	429 9.0 Pt
071044	421 11.4 Mi	421 10.5 Jo	417 8.4 Jo	425 7.9 Hf	452 9.4 Fd
386 4.8 Sl	422 11.2 Ra	440 10.5 GC	419 8.2 Je	440 8.5 Hf	U Boo
RR MON	425 11.3 Mi	443 10.4 Me	419 8.6 Cy	447 8.6 Wd	144918
071201	429 10.9 Cy	448 10.2 Mc	421 8.2 Jo	448 8.5 Hf	419 11.2 Cy
391 13.9 L	444 11.6 Mi	449 10.4 GC	425 8.3 Mi	452 8.7 Fd	429 12.0 Cy
449[13.4 GC	446 11.2 Pt	451 10.1 Mc	425 8.3 Hf	R VIR	S APS
V GEM	449 11.0 Hf	W CNC	426 7.9 Jo	123307	*145071*
071713	451 11.0 Wd	090425	427 8.0 Ra	426 7.5 Jo	380 10.1 En
391 14.4 L	V CNC	384 9.4 L	429 8.2 Je	RS UMA	383 10.0 Sl
449 12.3 GC	081617	419 10.9 Cy	429 **7.6 Cy**	123459	386 10.7 En
S CMI	391 9.1 L	423 10.6 Jo	440 7.5 Hf	384 11.2 Bm	393 10.1 En
072708	411 8.8 Ah	429 10.6 Cy	444 7.2 Mi	402 12.6 Bm	397 10.4 Sl
422 11.6 Ra	415 8.7 Ah	R CAR	446 7.5 Hf	416 12.9 Bn	Y LIB
446 12.1 Pt	419 8.3 Cy	*092963*	447 7.2 Wd	452 13.8 Fd	*150605*
452 12.0 Fd	423 8.0 Jo	386 8.4 Sl	448 7.3 Mc	S UMA	426 9.5 Jo
T CMI	425 8.4 Hf	X HYA	451 7.5 Mc	123961	S SER
072811	429 8.2 Cy	*003014*	453 7.4 Mc	411 8.7 Ah	151714
391 12.3 L	451 8.6 Mc	358 10.9 Bm	V HYA	414 8.5 Jo	385 9.3 L
446 11.2 Pt	RT HYA	369 11.3 Bm	*101620*	415 8.6 Ah	430 11.5 Cy
Z PUP	*082405*	378 11.4 Bm	384 7.7 L	422 8.8 Ra	S CRB
072820b	391 8.0 L	384 11.2 Bm	423 8.0 Jo	423 8.4 Jo	151731
347 9.3 Bm	391 8.6 Me	402 12.2 Bm	426 8.2 Jo	425 8.9 Hf	428 8.4 Ko
358 9.5 Bm	417 8.8 My	R LMI	428 8.5 Ko	440 8.5 Hf	S UMI
369 10.1 Bm	428 8.4 Ko	093934	W LEO	447 8.2 Wd	153378
378 10.4 Bm	449 8.8 GC	446[12.0 Pt	104814	448 8.2 Hf	419 11.3 Jo
384 10.6 Bm	451 8.1 My	RR HYA	378 10.0 Bm	448 **8.4 Mc**	427 10.8 Ra
402 10.8 Bm	R CHA	*004023*	384 10.0 Bm	452 8.6 Fd	429 12.5 Hf
449 12.4 GC	*082476*	358[12.8 Bm	384 10.2 L	RU VIR	429 12.5 Wd
U CMI	386 11.8 Sl	R LEO	402 10.7 Bm	124204	432 11.7 Pt
073508	U CNC	094211	429 12.3 Cy	430 12.5 Cy	443 12.5 Me
384 9.3 L	083019	391 6.1 Me	S LEO	T UMI	R CRB
419 9.0 Cy	449[13.9 GC	411 6.1 Ah	110506	133273	154428
429 9.1 Cy	X UMA	415 6.4 Ah	429 10.8 Cy	414 9.3 Jo	369 6.0 Kd
434 10.2 Cy	083350	419 7.4 Mi	T VIR	419 11.0 Cy	381 6.0 L
446 10.0 Pt	446[12.5 Pt	419 6.7 Hf	*120905*	429 11.3 Cy	385 6.0 L
S GEM	S HYA	420 6.8 Fd	384 10.2 L	444 11.9 Ra	391 6.1 L
073723	084803	425 6.7 Mi	R CRV	R CVN	392 5.6 Me
429 12.3 Cy	449 13.3 GC	425 6.6 Hf	*121418*	134440	408 6.0 Jo
444 11.0 Mi		434 6.9 Kp	402 14.0 Bm	423 7.8 Jo	423 6.0 Jo
446 9.9 Hf		440 7.0 Hf		426 7.8 Jo	426 6.0 Jo

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R CrB	SS Her	SV Sco	W Lyr	Nov Aql	RU Lyr
154428	162807	*174135*	181136	184300	190941
428 5.8 Ko	385 9.7 L	393[12.2 En	413 10.4 Jo	414 11.0 Jo	391 13.6 L
428 5.9 Pt	W Her	W Pav	417 10.9 Pk	419 10.8 Jo	U Dra
429 5.9 Pt	163137	*174162*	421 11.2 Ra	S Sct	190967
429 6.0 Cy	408 8.3 Jo	380 9.6 En	421 10.7 Jo	*184408*	422 13.5 Pf
430 6.0 Cy	414 8.4 Jo	393 9.7 En	RV Sgr	402 8.5 Ba	430 12.9 Pf
431 5.8 Pt	426 9.0 Jo	397 10.0 Sl	*182133*	S CrA	W Aql
432 5.9 Pt	428 8.9 Ko	U Ara	393 8.5 En	*185437a*	*191007*
439 6.0 Ba	R UMi	*174551*	SV Her	383 11.1 En	391 10.1 L
443 6.0 Ra	163172	393 10.8 En	182224	383 11.0 Sl	R Sgr
450 6.0 Ba	385 9.9 L	RT Oph	385 14.7 L	393 11.1 En	*191019*
X CrB	407 8.6 Jo	175111	SV Dra	396 10.7 En	381 12.6 L
154536	413 9.4 Jo	385 12.0 L	183149	397 10.8 Sl	RY Sgr
385 12.5 L	417 9.5 Sq	T Dra	391 10.8 L	ST Sgr	*191033*
R Ser	423 9.5 Jo	175458a	RZ Her	*185512a*	380[12.4 En
154615	427 9.4 Ra	385 13.1 L	183225	385 12.0 L	383[12.1 Sl
426 7.2 Jo	429 9.8 Wd	428 12.2 GC	391 11.0 L	R CrA	386[12.4 En
429 7.8 Cy	429 9.8 Hf	430 11.6 GC	413 10.0 Jo	*185537a*	402[12.4 En
432 7.2 Pt	449 9.7 GC	449 11.5 GC	X Oph	383 11.9 En	S Sgr
V CrB	R Dra	UY Dra	183308	383 13.0 Sl	*191319a*
154639	163266	175458b	391 8.0 L	393 12.5 En	381 12.0 L
408 7.7 Jo	413 12.0 Jo	385 10.9 L	408 8.4 Jo	397 12.5 Sl	383 12.5 En
413 7.9 Jo	423 12.0 Jo	428 10.8 GC	413 7.9 Jo	T CrA	Z Sgr
430 8.8 Cy	436 12.3 Jo	430 10.7 GC	421 7.8 Jo	*185537b*	*191321*
T CrB	S Her	449 10.9 GC	RY Lyr	383 12.8 En	393[12.1 En
155526	164715	RY Her	184134	383 13.0 Sl	SW Sgr
430 9.8 Pt	408 8.2 Jo	175519	391 10.1 L	Z Lyr	*191331*
RZ Sco	414 8.0 Jo	385 13.8 L	413 9.2 Jo	185634	383 11.8 En
155823	431 7.7 Lt	V Dra	R Sct	391 9.8 L	393 11.9 En
432 10.5 Pt	RS Sco	175654	*184205*	RT Lyr	TZ Cyg
U Ser	*164844*	385 12.8 L	349 5.9 Kd	185737	191350
160210	380 10.9 En	R Pav	356 5.9 Kd	385[14.6 L	413 10.5 Jo
432[12.0 Pt	RR Sco	*180363*	362 5.7 Kd	R Aql	421 10.5 Jo
SX Her	*165030a*	393 12.3 En	368 5.7 Kd	190108	U Lyr
160325	383 11.4 Sl	T Her	369 5.7 Kd	419 11.8 Jo	191637
385 8.0 L	RV Her	180531	373 5.5 Kd	426 11.8 Jo	413 10.9 Jo
417 8.2 Lt	165631	426 12.5 Jo	376 5.5 Kd	RX Sgr	419 10.8 Jo
428 8.1 Ko	385 14.7 L	W Dra	383 5.2 Sl	*190818*	421 10.8 Jo
429 8.0 Pt	RW Sco	180565	384 5.8 Kd	383 11.1 En	421 11.8 Ra
431 7.9 Pt	*170833*	381 11.4 L	385 5.1 L	386 10.9 En	426 10.7 Jo
432 8.0 Pt	380 10.9 En	428 9.8 GC	392 5.6 Me	391 11.1 L	AF Cyg
RU Her	RS Her	430 10.1 GC	393 5.8 Kd	393 10.9 En	192745
160625	171723	430 10.0 Pf	394 5.8 Kd	396 10.6 En	412 6.7 Ah
385 10.5 L	408 8.8 Jo	440 9.7 GC	395 5.9 Kd	402 10.4 En	415 6.8 Ah
428 7.3 Ko	412 9.2 Ah	449 9.7 GC	397 5.9 Kd	RW Sgr	417 6.8 Ra
430 7.4 Cy	414 9.0 Jo	X Dra	402 5.6 Ba	*190819a*	TY Cyg
R Sco	415 9.5 Ah	180666	408 5.9 Jo	383 9.6 En	192928
161122a	S Oct	426 10.7 Jo	413 6.4 Kd	386 9.5 En	385 13.3 L
356[14.3 Bm	*172486*	430 12.5 Pf	414 6.0 Jo	391 9.6 L	RT Aql
S Sco	383 12.7 Sl	430 12.5 GC	414 5.9 Cy	393 9.5 En	193311
161122b	397 13.0 Sl	440 12.3 GC	417 6.3 Ba	396 9.5 En	385 13.6 L
356 13.4 Bm	RU Oph	449 11.9 GC	417 6.5 Kd	402 9.3 En	415 13.3 B
W CrB	172809	TV Her	419 6.2 Jo	S Lyr	R Cyg
161138	385 13.3 L	181031	419 6.8 Cy	190925	193449
432 11.2 Pt	RU Sco	391 14.0 L	421 6.4 Jo	385 14.4 L	412 11.5 Pk
U Her	*173543*	W Lyr	423 6.7 Jo	RS Lyr	412 11.0 Ah
162119	380 9.4 En	181136	426 6.5 Jo	190933a	413 10.7 Jo
430 11.7 Cy	393 9.1 En	391 8.8 L		381 12.9 L	415 10.7 Ah
		412 10.0 Ah			415 10.5 Ra

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1934.

J.D.Est.	Obs.	J.D.Est.	Obs.	J.D.Est.	Obs.	J.D.Est.	Obs.	J.D.Est.	Obs.	J.D.Est.	Obs.
R CYG		TU CYG		S PAV		RU AQL		WX CYG		ST CYG	
193449		194348		*194659*		200812		201437b		202954	
417	10.4 Jo	423	10.1 Pt	383	6.5 Sl	387	9.6 L	426	11.2 SR	423	10.7 Jo
418	9.9 B	424	10.1 Ry	393	7.5 En	419	12.0 B	427	11.2 SR	432	11.3 B
419	9.5 Jo	429	10.0 B	397	6.7 Sl	Z AQL		428	11.2 B	V VUL	
421	9.0 Jo	429	10.1 Wd	RR SGR		*200906*		429	11.3 Wd	203226	
421	9.4 Pk	440	10.7 Hf	*194929*		356	13.4 Bm	430	11.1 Cy	423	8.5 Pt
421	9.7 Ra	446	11.0 Wd	393	8.0 En	381	13.6 Bm	442	11.3 SR	Y DEL	
423	9.5 Pt	X AQL		RU SGR		404	10.8 Bm	443	11.2 SR	203611	
423	8.8 Jo	194604		*195142*		421	10.0 Jo	444	11.2 SR	415	13.8 B
426	9.0 Pk	385	12.9 L	393	12.5 En	426	9.6 Jo	446	11.2 SR	S DEL	
429	9.1 Wd	413	[12.3 Hi	RR AQL		R SGE		446	11.3 Wd	203816	
429	9.0 Oy	χ CYG		*195202*		200916		449	11.4 SR	414	11.3 Jo
435	8.4 Jo	194632		391	14.3 L	413	9.2 Jo	V SGE		415	11.3 B
435	8.2 Ko	356	7.7 Kd	415	13.3 B	419	8.9 Jo	201520		423	11.9 Jo
435	8.0 Je	360	7.4 Kd	RS AQL		423	9.2 Jo	416	11.2 Me	425	12.0 B
437	8.3 B	367	7.3 Kd	*195308*		RS CYG		417	10.7 Jo	429	12.0 B
440	8.3 Hf	369	7.2 Kd	387	10.2 L	200938		418	11.0 SR	V CYG	
445	8.0 Mc	373	7.2 Kd	Nov CYG		407	8.5 Jo	421	11.0 SR	203847	
445	6.8 Bd	385	7.2 Kd	195553		413	8.7 Jo	421	11.0 Jo	387	13.7 L
446	7.7 Wd	393	6.9 Kd	423	[12.2 Pt	415	8.9 Ra	U CYG		420	12.9 B
448	8.0 Hf	394	6.8 Kd	RR TEL		417	8.7 Jo	201647		421	11.0 Jo
451	7.5 Mc	401	6.0 Kd	*195656*		419	9.0 Je	407	9.0 Jo	432	12.7 B
453	7.8 Mc	407	5.7 Jo	393	12.6 En	419	9.1 Cy	412	8.7 Pk	Y AQR	
RV AQL		409	5.5 Kp	Z CYG		421	8.8 Jo	413	9.0 Jo	*203905*	
193509		413	5.5 Jo	195849		423	8.8 Pt	415	9.9 Ra	356	14.6 Bm
381	11.8 L	414	5.1 Kp	407	8.5 Jo	423	9.0 Sx	416	9.3 B	376	14.4 Bm
T PAV		415	5.0 Kp	413	8.6 Jo	426	8.8 Jo	417	8.3 Sq	381	14.0 Bm
193972		415	5.2 Ra	417	8.8 Jo	429	8.8 Je	417	9.3 Jo	404	11.2 Bm
383	13.7 Sl	417	4.9 Kp	419	8.6 Jo	429	9.0 Wd	419	9.6 Jo	414	9.9 Jo
393	13.2 En	417	5.1 Jo	423	8.7 Jo	430	9.1 Cy	419	9.9 Je	419	9.5 Jo
397	13.1 Sl	417	5.3 Oy	423	8.9 Pt	435	8.4 Ko	419	9.8 So	421	9.5 Jo
RT CYG		418	5.6 B	429	8.8 B	435	8.2 Je	422	9.5 B	426	9.4 Jo
194048		418	5.3 Hf	440	9.2 Hf	440	8.8 Hf	423	10.8 Sx	T DEL	
412	12.4 Ah	419	5.1 Je	444	9.4 Ra	446	8.9 Wd	423	9.8 Pt	204016	
413	11.9 Jo	419	5.0 Jo	449	9.4 Hf	446	8.7 Bd	423	8.9 Pk	387	9.8 L
417	11.8 Jo	421	4.9 Jo	S TEL		449	8.9 Hf	426	9.5 Jo	414	10.9 Jo
419	11.7 Jo	423	4.5 Jo	*195855*		R DEL		429	10.5 Je	415	10.6 B
421	11.8 Jo	423	5.3 Pt	393	12.6 En	201008		429	10.0 Wd	423	11.3 Jo
421	11.0 Ra	423	5.2 Sx	SY AQL		387	12.8 L	435	9.5 Je	V AQR	
423	10.7 Pt	426	5.1 Jo	200212		414	12.5 My	446	10.1 Wd	204102	
423	12.0 Jo	429	5.0 Kp	387	10.7 L	SX CYG		451	9.9 Mc	392	8.5 Lt
429	9.4 Oy	429	5.5 Wd	407	11.0 Jo	201130		RU CAP		426	9.1 Jo
429	10.2 Wd	429	4.9 Ko	414	12.0 Jo	416	[13.3 B	*202622*		W AQR	
429	9.9 B	429	5.5 Oy	S CYG		423	[12.0 Pt	376	12.3 Bm	*204104*	
440	9.8 Hf	429	5.3 Hf	200357		WX CYG		381	11.8 Bm	356	12.0 Bm
446	8.9 Wd	432	5.2 Kp	423	[12.4 Pt	201437b		404	9.2 Bm	376	12.6 Bm
449	8.7 Hf	434	5.2 Kp	R CAP		407	10.4 Jo	Z DEL		381	12.8 Bm
451	9.2 Mc	434	5.5 Hf	*200514*		413	10.4 Jo	202817		387	11.9 L
453	8.7 Mc	435	5.5 Je	391	12.4 L	416	11.2 SR	387	9.5 L	404	13.2 Bm
TU CYG		435	5.4 Jo	S AQL		417	10.5 Jo	413	9.5 Hi	U CAP	
194348		435	5.3 Kp	200715a		418	11.2 SR	419	9.2 Jo	*204215*	
410	10.1 Ry	435	5.4 Cy	413	9.7 Jo	419	11.2 SR	423	9.0 Jo	387	10.9 L
413	10.4 Jo	440	5.6 Hf	419	9.5 Jo	419	11.0 Cy	428	9.8 B	416	12.3 B
414	10.0 Ry	442	5.6 Bd	423	9.4 Jo	419	10.7 Jo	ST CYG		V DEL	
417	10.0 Ry	443	5.5 Ra	RW AQL		421	10.7 Jo	202954		204318	
417	10.0 Jo	446	5.5 Ra	200715b		421	11.0 Ra	387	12.3 L	387	13.6 L
419	9.7 Jo	446	5.7 Wd	413	9.0 Jo	421	11.2 SR	414	11.0 Jo	425	[13.4 B
421	9.7 Jo	447	5.3 Bd	419	9.2 Jo	423	11.0 Jo	420	11.6 B		
423	9.8 Jo	449	5.9 Hf	423	9.0 Jo	423	10.6 Bd	423	11.6 Pt		

Variable Star Observations Received During January, 1934.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
T Aqr			X Cap			T Cap			U Aqr			RW Peg			ST And		
204405			*210221*			*211615*			*215717*			225914			233335		
407	7.6	Jo	391	12.0	L	391	11.4	L	420	12.1	B	419	13.2	B	428	9.3	B
412	7.7	Ah	X Cep			Y Cap			RT Peg			421	12.5	Ra	437	9.1	B
413	7.6	Jo	210382			*212814*			215934			421	13.1	Wa	440	9.4	Hf
415	7.7	Ah	387	14.1	L	391	14.3	L	419[	13.5	B	427	13.3	Wa	447	9.4	Hf
419	7.6	Jo	RS Aqr			W Cyg			RZ Peg			442	13.8	B	451	9.0	My
421	7.9	Jo	*210504*			213244			220133b			449	13.3	Wa	R Aqr		
426	8.0	Jo	391	10.5	L	356	6.6	Kd	416	11.6	B	R Peg			*233815*		
RZ Cyg			416	11.4	B	367	6.5	Kd	419	11.6	B	230110			369	7.4	Kd
204846			Z Cap			373	6.5	Kd	419	12.7	Cy	413	10.2	My	373	7.4	Kd
413	11.4	SR	*210516*			387	6.5	L	T Peg			421	9.8	Jo	384	7.5	Kd
418	11.4	SR	376	13.2	Bm	393	6.6	Kd	220412			422	10.3	Ra	398	7.9	Kd
419	11.4	SR	381	13.2	Bm	402	6.6	Kd	421[	13.6	B	424	10.4	Pt	407	8.3	Jo
419	11.7	B	391	13.8	L	417	6.1	Oy	Y Peg			V Cas			414	8.7	Jo
421	11.5	Wa	404[	12.8	Bm	429	5.9	Oy	220613			230759			417	8.7	Pk
421	11.4	SR	R Equ			445	6.3	Mc	356	13.2	Bm	411	8.3	SR	417	8.7	Sq
423	11.5	Pt	210812			451	6.3	Mc	381[	13.9	Bm	411	8.2	Ah	418	8.5	B
426	11.6	SR	419	13.5	B	S Cep			421[	13.7	B	415	8.2	Ah	419	8.7	Jo
427	11.6	SR	T Cep			213678			RS Peg			419	8.7	Cy	422	9.0	Ra
427	11.9	Wa	210868			417	10.7	Jo	220714			424	8.1	Pt	423	9.1	Sx
432	11.8	B	407	8 1	Jo	419	10.6	Jo	356	14.0	Bm	428	8.5	B	424	8.5	Pt
440	11.9	Wa	411	8.1	Ah	419	11.5	Gh	376	12.8	Bm	429	8.2	Ko	426	8.9	Jo
442	11.9	SR	415	8.2	Ah	419	11.5	Cy	381	11.8	Bm	435	9.2	Cy	429	9.4	Hf
444	11.9	SR	417	8.0	Jo	423	10.7	Jo	404	10.2	Bm	437	9.0	B	429	9.4	Wd
446	11.9	SR	417	8.4	Oy	427	11.3	Ra	421	10.2	Bm	440	9.4	Hf	430	9.8	Ko
447	11.9	SR	417	8.3	Sq	428	10.6	B	X Aqr			W Peg			440	9.5	Hf
447	12.6	Wa	423	8.0	Sx	429	11.0	Hf	*221321*			231425			Z Cas		
449	12.7	Wa	423	8.2	Bd	429	11.0	Wd	356	9.5	Bm	419	11.2	Cy	233956		
449	11.9	SR	423	8.2	Pt	430	11.3	GC	376	8.2	Bm	423	10.2	Jo	420	13.3	B
449	11.9	GC	423	7.9	Jo	440	10.7	GC	381	8.4	Bm	S Peg			442	11.4	B
X Del			425	7.3	Ar	449	10.9	GC	404	8.9	Bm	231508			RR Cas		
205017			427	7.2	Ar	RU Cyg			S Gru			412	8.7	Ah	235053		
387	12.7	L	427	8.4	Ra	213753			*221948*			415	8.7	Ah	419	12.3	B
420	11.1	B	428	7.3	Ar	407	7.5	Jo	396	10.7	En	419	8.8	Cy	442	13.1	B
423	10.8	Jo	429	7.6	Ko	410	7.7	Ry	402	11.1	En	423	10.5	Jo	444	12.4	Ra
UX Cyg			429	8.2	Oy	414	7.5	Ry	S Lac			428	8.8	B	R Tuc		
205030a			429	7.9	B	414	7.5	Jo	222439			432	9.0	B	*235265*		
426	10.3	Jo	429	8.2	Hf	415	8.0	Ah	416	12.6	B	437	9.1	B	386	13.3	En
R Vul			429	8.1	Wd	417	7.5	Ry	428	12.8	B	448	9.5	Hf	386	13.5	Sl
205923a			431	7.3	Ar	419	8.0	Cy	R Lac			Z And			397	12.0	Sl
412	8.7	Ah	432	8.5	Kp	419	7.9	Je	223841			232848			R Cas		
413	8.5	Jo	433	7.2	Ar	421	7.5	Jo	423	9.3	Jo	392	10.8	Me	235350		
415	8.5	Ah	440	8.1	Hf	426	7.6	Jo	430	10.0	GC	416	10.8	Me	419	10.3	B
417	8.5	Jo	442	8.0	Bd	429	7.9	Je	435	9.7	Gh	419	10.9	Cy	423	10.5	Jo
419	8.7	Jo	445	8.1	Bd	RR Peg			440	9.9	GC	419	10.9	Gh	425	10.4	Ar
423	8.6	Jo	445	7.8	Sx	214024			440	9.9	Hf	423	10.1	Pk	427	10.5	Ar
423	8.6	Pt	446	8.0	Wd	416	12.4	B	447	10.4	Hf	435	10.8	Cy	428	10.8	Ar
426	9.0	B	447	8.1	Hf	418	12.7	B	449	10.1	GC	436	10.6	Ko	431	10.8	Ar
435	8.8	Jo	447	7.8	Ra	R Gru			S Aqr			443	10.8	Me	432	10.4	B
V Cap			447	7.8	Bd	*214247*			*225120*			444	10.7	Ra	444	11.4	Ra
210124			453	7.3	Mc	392	8.6	En	391[	14.2	L	447	10.7	Hf	447	12.2	Wd
391	10.1	L	RR Aqr			396	9.0	En	421[	12.5	Jo	449	10.6	SR	Z Peg		
TW Cyg			*210003*			402	9.5	En	RW Peg			450	10.9	Me	235525		
210129			391	13.0	L	V Peg			225914			ST And			414	8.0	Jo
381	14.2	Bm	416	13.4	B	215605			356	10.2	Bm	233335			423	8.0	Jo
387	14.1	L	X Peg			416	14.0	B	376	11.0	Bm	414	10.0	My	424	7.8	Pt
415	14.0	B	211614			U Aqr			383	11.6	Bm	421	9.0	Jo	441	9.3	So
			415	11.3	B	*215717*			404	12.2	Bm	424	10.0	Pt	449	10.6	So
			422	12.0	B	387	12.1	L	416	13.1	B	426	8.9	Jo			

Rapidly Varying Irregular Variables.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
005840 RX Andromedae—						
	7391.9	11.3	Me	7424.3	11.3	Ry
	7392.8	11.0	Me	7426.7	11.3	Pt
	7410.4	12.1	Ry	7426.7	11.0	SR
	7411.4	12.7	Ry	7427.7	11.3	SR
	7414.4	12.7	Ry	7442.6	13.1	SR
	7415.4	12.1	Ry	7443.6	13.4	SR
	7416.4	11.1	Ry	7443.7	13.2	Me
	7416.6	11.0	Me	7444.6	13.2	Me
	7417.4	11.1	Ry	7444.7	13.4	SR
	7418.6	11.1	SR	7446.7	13.0	Pt
	7419.7	11.8	SR	7449.5	10.5	So
	7419.9	11.6	Cy	7449.6	10.6	SR
	7420.5	12.4	Ry	7450.7	10.4	Me
	7421.7	11.8	SR			
060547 SS Aurigae—						
	7347.5	14.8	Bm	7422.6	13.9	B
	7358.5	14.6	Bm	7423.6	12.7	Jo
	7369.5	14.3	Bm	7424.5	13.2	Ry
	7378.5	13.9	Bm	7426.7	12.5	Pt
	7384.5	13.2	Bm	7427.6	13.2	Wa
	7385.3	13.9	L	7428.6	13.8	GC
	7391.7	14.7	L	7429.8	12.5	Cy
	7391.9	13.5	Me	7430.9	12.5	Cy
	7392.8	13.2	Me	7431.9	12.5	Pt
	7402.4	14.8	Bm	7432.9	12.5	Pt
	7406.2	13.9	Bm	7439.5	12.6	B
	7410.4	11.5	Ry	7440.5	13.3	GC
	7411.5	11.8	Ry	7442.5	11.2	B
	7412.4	11.3	Ry	7442.6	11.2	SR
	7412.6	11.2	B	7443.5	11.6	B
	7413.5	11.5	Cy	7443.7	11.3	Me
	7413.6	11.4	B	7444.5	11.8	B
	7414.4	12.0	Ry	7444.6	12.4	SR
	7414.6	11.7	Mg	7444.6	12.2	Me
	7415.4	12.4	Ry	7444.7	12.0	Pt
	7415.6	12.3	B	7445.7	12.6	Pt
	7416.4	13.0	Ry	7447.6	14.6	Wa
	7416.6	12.9	B	7449.6	13.9	GC
	7416.6	13.0	Me	7449.6	13.3	So
	7418.6	14.0	B	7450.6	13.2	Me
	7420.6	14.2	B			
074922 U Geminorum—						
	7347.5	14.2	Bm	7430.9	12.4	Cy
	7358.5	13.3	Bm	7431.9	12.4	Pt
	7369.5	14.5	Bm	7432.9	12.4	Pt
	7378.5	13.7	Bm	7434.9	12.4	Cy
	7384.7	14.0	L	7441.6	12.4	B
	7391.7	14.4	L	7442.6	13.8	B
	7402.5	13.9	Bm	7443.7	13.3	Me
	7419.6	12.4	Cy	7444.6	12.4	Me
	7421.7	12.7	Jo	7446.7	12.4	Pt
	7426.7	12.3	Pt	7448.7	12.4	Pt
	7427.7	12.3	Pt	7449.6	13.8	GC
	7428.6	13.8	GC	7450.7	13.3	Me
	7429.6	12.4	Cy			
081473 Z Camelopardalis—						
	7381.3	12.2	L	7391.7	11.6	L
	7385.3	13.3	L	7391.9	11.5	Me
	7391.3	11.3	L	7392.8	11.4	Me

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
081473 Z Camelopardalis—						
	7410.4	12.1	Ry	7428.7	11.4	Pt
	7411.5	12.0	Ry	7429.9	11.8	Cy
	7412.4	11.8	Ry	7431.7	11.8	Pt
	7414.4	11.7	Ry	7432.9	12.3	Pt
	7415.4	11.3	Ry	7440.5	13.5	GC
	7416.5	11.5	Ry	7443.7	13.1	Me
	7416.6	11.5	Me	7444.6	13.2	Me
	7417.4	11.8	Ry	7446.7	12.3	Pt
	7419.8	11.7	Cy	7448.7	12.3	Pt
	7420.5	11.9	Ry	7449.6	13.4	GC
	7423.7	11.2	Pt	7450.6	13.1	Me
	7424.5	11.6	Ry	7450.7	12.4	Pt
	7427.7	11.9	Pt	7451.6	12.5	GC
	7428.6	11.3	Ko	7453.6	10.5	GC
	7428.6	11.2	GC			
094512 X Leonis—						
	7391.9	12.4	Me	7450.7	12.0	Me
174406 RS Ophiuchi—						
	7349.9	9.1	Kd	7384.9	10.7	Kd
	7368.9	9.1	Kd	7385.3	11.1	L
	7369.9	9.7	Kd	7391.2	11.3	L
	7376.9	10.0	Kd	7392.9	11.2	Kd
	7381.2	10.6	L			
202946 SZ Cygni—						
	7420.7	9.5	Pt	7438.7	9.3	Pt
	7423.7	9.7	Pt	7440.7	9.0	Pt
	7424.7	9.5	Pt	7444.7	9.5	Pt
	7426.7	9.0	Pt	7445.7	9.5	Pt
	7427.7	9.0	Pt	7446.7	9.4	Pt
	7428.7	9.0	Pt	7448.7	9.5	Pt
	7429.7	9.2	Pt	7450.7	9.7	Pt
	7437.7	9.7	Pt			
213843 SS Cygni—						
	7381.4	11.7	L	7417.5	11.9	Jo
	7385.3	12.1	L	7417.6	12.1	Pk
	7387.4	12.2	L	7418.5	12.1	B
	7391.3	12.2	L	7418.6	11.5	SR
	7392.8	11.8	Me	7419.5	11.8	Jo
	7392.8	11.8	SR	7419.5	12.0	B
	7394.6	11.8	SR	7419.6	11.5	SR
	7396.7	12.1	SR	7419.6	11.6	So
	7400.7	11.8	SR	7419.6	12.0	Cy
	7407.5	11.8	Jo	7420.5	11.7	B
	7408.5	11.9	Jo	7420.6	11.3	Mi
	7412.2	11.9	Ah	7420.7	11.7	Pt
	7412.6	12.0	Pk	7421.5	11.8	Jo
	7412.7	11.8	SR	7421.5	12.0	Wa
	7413.5	11.9	Jo	7421.6	12.0	B
	7413.7	11.5	SR	7421.6	11.8	SR
	7414.5	11.9	Jo	7421.7	12.0	Pk
	7414.7	12.0	Pk	7421.7	12.1	Ra
	7415.2	11.8	Ah	7422.5	12.0	B
	7415.5	11.7	Mi	7423.5	11.9	Jo
	7415.5	12.0	B	7423.5	12.0	B
	7415.6	11.5	SR	7423.6	11.5	Mi
	7416.6	11.9	B	7423.7	12.0	Pk
	7416.6	11.7	Mi	7423.7	11.6	Pt
	7416.6	11.6	Me	7424.6	12.0	Pk
	7416.6	11.5	SR	7424.7	11.6	Pt

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1934.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	Star	J.D.	Est.Obs.	J.D.	Est.Obs.
213843 SS CYGNI—					213843 SS CYGNI—				
	7425.5	11.9 Ar	7430.6	11.9 Cy		7443.5	8.5 B	7447.5	8.2 GC
	7425.5	12.0 B	7431.6	11.8 Ar		7443.5	8.2 Mi	7447.5	8.8 Hf
	7425.5	11.5 Mi	7432.5	11.9 B		7443.6	8.5 SR	7447.5	8.5 Wd
	7426.5	12.0 Jo	7433.5	11.9 B		7443.7	8.4 Me	7447.6	8.5 Wa
	7426.5	12.0 B	7433.6	11.8 Ar		7444.5	8.4 Mi	7447.6	8.2 Bd
	7426.6	11.8 SR	7434.6	11.9 Wa		7444.5	8.4 Hf	7447.7	8.4 So
	7426.7	12.1 Pk	7435.5	11.9 Jo		7444.5	8.4 Wd	7447.7	8.8 SR
	7426.7	11.6 Pt	7435.5	11.8 B		7444.5	8.5 B	7448.5	8.4 Hf
	7427.6	11.8 SR	7435.5	11.8 Cy		7444.6	8.5 SR	7448.5	8.6 Wd
	7427.6	11.9 Ar	7437.5	10.3 B		7444.6	8.5 Me	7448.7	8.5 Pt
	7427.6	12.1 Wa	7437.7	10.8 Pt		7444.6	8.2 Ra	7449.5	8.6 GC
	7427.7	11.7 Pt	7438.5	9.1 B		7444.7	8.3 Pt	7449.5	8.6 Hf
	7428.5	12.0 B	7438.7	9.2 Pt		7445.5	8.4 Mi	7449.5	8.4 So
	7428.5	11.8 GC	7440.5	8.9 B		7445.6	8.5 B	7449.5	8.8 Wa
	7428.7	11.6 Pt	7440.5	9.0 GC		7445.6	8.2 Bd	7449.5	8.7 Wd
	7429.5	11.8 Ko	7440.5	8.6 Hf		7445.7	8.3 Pt	7449.6	9.1 SR
	7429.5	11.9 B	7440.6	8.9 Wa		7446.5	8.4 Mi	7450.7	8.9 Pt
	7429.5	12.1 Hf	7440.7	9.1 Pt		7446.5	8.5 Hf	7451.6	9.0 Ae
	7429.5	12.0 Wd	7441.6	8.7 B		7446.5	8.4 Wd	7451.6	8.5 Mc
	7429.7	11.7 Pt	7442.5	8.6 B		7446.6	8.4 Bd	7453.6	9.2 Mc
	7430.5	12.0 B	7442.5	8.4 Mi		7446.6	8.8 SR	7454.6	9.5 Ae
	7430.5	11.7 GC	7442.6	8.8 SR		7446.7	8.3 Pt		

SUMMARY FOR JANUARY, 1934.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	23	38	Loreta	Lt	7	17
Allen, L. B.	Ae	1	2	McKnelly	My	22	59
Armfield	Ar	6	28	McLeod	Mc	12	20
Ballhaussen	Ba	3	5	Meek	Me	27	67
Bappu	Bm	36	136	Miller	Mi	16	45
Bordes	Bd	15	36	O'Byrne	Oy	10	16
Bouton	B	79	160	Peltier	Pt	97	167
Brown	Bn	2	3	Perkinson	Pk	10	23
Cilley	Cy	55	95	Preucil	Pf	6	7
Ensor	En	39	63	Raphael	Ra	57	66
Ford	Fd	14	15	Rosebrugh	Rb	2	2
Georgetown	GC	32	59	de Roy	Ry	8	35
Gooch	Gh	3	3	Salanave	Sx	20	26
Hartmann	Hf	53	110	Scanlon	Sc	23	27
Hildom, A	Hi	2	2	Shinkfield	Sl	22	28
Hood	Hd	1	1	Skora	SR	12	90
Jansen	Je	11	26	Smith, F. P.	Sq	6	7
Jones	Jo	115	310	Smith, F. W.	Sf	8	8
Kanda	Kd	9	47	Smith, L.	Sh	2	3
King	Kg	2	2	Wade	Wh	6	7
Kirkpatrick	Kp	3	10	Watson	Wa	11	19
Kohman	Ko	24	24	Webb	Wd	41	65
Lacchini	L	121	135				
Leuchinger	Lr	1	1	Total		46	328	2115

The Spring meeting of the Association will be held at the new Fels Planetarium of the Franklin Institute in Philadelphia on May 26.

LEON CAMPBELL, *Recorder.*

February 10, 1934.

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

During the past year interest in meteoric astronomy has constantly increased, as is shown not only by the great activity of the American Meteor Society and volunteer observers reporting thereto, but also by the founding in America of another society, for the special study of meteorites. We have also been informed of the founding of several societies of amateurs in various localities, part of whose time will be spent in the study and observation of meteors. The observatories which have devoted some energy to this work continue to do so. We may add that the press very gladly publishes both requests for observations and reports of conclusions based thereon, in this way spreading some knowledge of the subject to millions of readers.

In the American Meteor Society itself, we have had a considerable increase in membership, and have had several regional groups begin work or take on great activity in 1933. Among the former the Wisconsin-North Illinois group deserves special notice; among the latter, the Tennessee-Kentucky and Missouri-Illinois groups. The outstanding event of the year in America was the Leonid shower in November, for although it was in itself miserably disappointing, yet because of it hundreds of persons learned something about the observation of meteors, and the regional groups had fine training in coöperative work. It is as yet far too early to report on the success of this campaign, but there is no doubt that it will eventually net considerable number of heights for the Leonid epoch. As the nights were bitterly cold, it needed real enthusiasm for the average person to stick out the long hours, but literally hundreds did so. Had the shower been a rich one, the perfect organization would have secured results breaking all records.

In Arizona, J. D. Williams has continued his special work, with the able assistance of D. F. Brinegar and R. Knabe. We believe that Williams' annual total of 9161 meteors plotted on 137 nights sets a new world record for any observer. As the work was carefully planned, and has been carried out in the splendid climate of Arizona by an able observer, its discussion added to that of Williams' past two years of work should give more definite answers to certain problems than have yet been attainable.

In Oregon, J. H. Pruett had great success in the gathering of data on several great fireballs appearing over that state. To both O. E. Monnig and J. D. Williams we are indebted for numerous data that have permitted investigation of the great fireball seen over Oklahoma-Texas-New Mexico on 1933 March 24. The outstanding achievement of the group under Sterling Bunch was the collection of data on the Tennessee fireball of 1933 August 21 which permitted the calculation not only of heights but of the vastly more important train drift. The paper containing the results, the joint work of Bunch and Olivier, is about to appear in the *U. S. Monthly Weather Review*. We hope to distribute reprints to our members.

Flower Observatory Reprint No. 22 is being mailed to (1) those members who have paid their dues for 1934 and (2) those members who have sent in worthwhile observations for 1933. Members who fall in neither category may receive reprints by paying their dues for 1934.

In the annual report, in general the meteors for Table I were plotted and those for Table II were not plotted. The total number for the year, 61,989 observations, will be increased by records not yet received. For instance, the work of the Texas section has been partly printed in the *Texas Observers' Bulletin*, but,

as the originals have not arrived here, according to rule we cannot include it. For some fireballs anywhere from 20 to 80 observations have been received; these are not counted separately, but only as one fireball each.

For reports received during the year, we are as usual under obligation to the U. S. Weather Bureau and to the Hydrographic Office, U. S. Navy. Also the press, in all parts of the country, has given cordial aid and greatly contributed to the success of the year's work. We hope for even better things in 1934.

TABLE I.

Name and Station	Nights	Meteors
Adamson, G. H., Tecumseh, Michigan	3	109*
Alpha Nu Fraternity, Beta Chapter, Denver, Colorado	3	786*†
Armfield, L. E., Milwaukee, Wisconsin	4	102
Armfield, Mrs. L. E., Milwaukee, Wisconsin	2	189*
Baines, Wm., Okanogan, Washington	9	86*
Blair, Mrs. J. H., East Point, Georgia	6	163
Bowman, E. F. (Heart of America Amateur Astronomers) Kansas City, Missouri	7	990*†
Brinegar, D. F., Tucson, Arizona	58	2826
Bryan, E. H., Jr., Honolulu, T. H.	6	236*
Bunch, S., Knoxville, Tennessee	6	199
Bunch, Mrs. S., Knoxville, Tennessee	2	43*
Butler, R. B., Plainfield, New Jersey	4	68
Buttles, L. I., Chicago, Illinois	2	47†
Darling, B. C., Elsie, Michigan	2	53
De Roy, F., Antwerp, Belgium	1	2940*†
Deutsch, A., Chicago, Illinois	1	41
Dupree, H. M., East Point, Georgia	2	42
Eason, J. C., East Point, Georgia	3	134*
Evans, J. W., Upper Darby, Pennsylvania	2	56
Geddes, M., Otekura, New Zealand	9	177
Graham, J. W., Salem, Oregon	4	172*
Harwood, Miss M., Nantucket, Massachusetts	2	106*
Hayes, J. J., Salt Lake City, Utah	2	50
Heines, N. J., Paterson, New Jersey	2	114
Holm, M., St. Paul, Minnesota	3	122
Jones, W., Bristol, Tennessee	3	79
Kenney, W. G., Freeport, New York	2	53
Khan, Mohd. A. R., Deccan, N. S. R., India	9	139*
Kirkpatrick, G. P., Piermont, New York	14	266
Klapperich, A. J., Wilmette, Illinois	3	42*
Knabe, R., Tucson, Arizona	45	2557
Komori, A., Honolulu, T. H.	2	180*
Kusner, J. H., Gainesville, Florida	7	180
La Paz, L., Columbus, Ohio	2	88
Loreta, E., Bologna, Italy	7	51
Louisville Astronomical Society, Louisville, Kentucky	3	348†
Marsh, F. F., Frederick, Maryland	3	62
Miller, R. W., Miami, Florida	1	58
Molyneaux, D., Binghamton, New York	3	85
Niebuhr, V. J., Reedsburg, Wisconsin	3	49
O'Byrne, S. L., Webster Groves, Missouri	4	230
Olivier, C. P., Upper Darby, Pennsylvania	3	93
Paterson, J. F., Broken Hill, Australia	2	46
Persons, W. J., Kalamazoo, Michigan	16	277
Preucil, F., Joliet, Illinois	5	41
Reich, E. R., Marshfield, Wisconsin	2	55
Ridley, G. W., San Francisco, California	2	55
Rupert, S., Exeter, California	3	223*
Schenkman, A., New Brunswick, New Jersey	6	53
Shinkfield, R. C., Adelaide, South Australia	?	100

Name and Station	Nights	Meteors
Simpson, J. W., Webster Groves, Missouri	36	1332*
Smith, F. W., Glenolden, Pennsylvania	30	311
Smith, T. T., Tucson, Arizona	15	341
Steadman, Miss L., Honolulu, T. H.	1	40*
Tomkins, C. B., West Point, Pennsylvania	3	78
Tomkins, T. K., North Hills, Pennsylvania	4	55
Tonkin, A., Knoxville, Tennessee	2	48
Urquhart, Miss S. M., Detroit, Michigan	9	247
Wamer, W. P., St. George, S. C.	4	111
Watson, P. S., Sykesville, Maryland	3	47
Weed, F., Jr., Jefferson City, Tennessee	7	47
West, J. Y., East Radford, Virginia	2	51*
Williams, C. I., King George, Virginia	2	41*
Williams, J. D., Tucson, Arizona	137	9161
Wilson, L. J., Franklin, Kentucky	5	75
Wilson, R. H., Upper Darby, Pennsylvania	3	62
1932:		
Bateson, F. M., Wellington, New Zealand	14	168
34 members reporting less than 40 each in 1933	54	581
		28,057

*Most or all of these were not plotted.
†Group of observers.

TABLE II.

Arizona Observers, Arizona	—	1000
Hannon, A. M., Carmel, California	63	431*
Hickerson, J. F., Webster Groves, Missouri	6	232†
Lindsay, P. M., Los Angeles, California	12	328*
Milwaukee Astronomical Society, Milwaukee, Wisconsin	8	1120†
Missouri-Illinois Observers, Missouri and Illinois	32	2418†
Simpson, A. M., Webster Groves, Missouri	9	742
Stone, W. R., Santa Barbara, California	12	189
Weatherford Astronomical Society, Weatherford, Texas	2	183
9 non-members reporting on miscellaneous dates	17	491
		7,134

*Most or all of these were plotted.
†Some of these were plotted.

TABLE III.

TELESCOPIC METEORS.

Armfield, L. E., Milwaukee, Wisconsin	133*
Chandra, R. G., Jessore, India	15
Dermul, A., Antwerp, Belgium	7
Douglas, A. E., Tucson, Arizona	1
Flower Observatory, Upper Darby, Pennsylvania	23
Friton, E. E., St. Louis, Missouri	1
Houston, W., Madison, Wisconsin	4
Jones, E. H., Goffstown, New Hampshire	27
Kirkpatrick, G. P., Piermont, New York	1
Knabe, R., Tucson, Arizona	2
Miller, R. W., Lansdowne, Pennsylvania	10
Nassau, J. J., Cleveland, Ohio	1
Peltier, L. C., Delphos, Ohio	15
Shinkfield, R. C., Adelaide, South Australia (1932)	6
Simpson, J. W., Webster Groves, Missouri	2
Smith, F. W., Glenolden, Pennsylvania	2
Smith, T. T., Tucson, Arizona	2
	252
Previously unreported 1932 Perseids	684

*100 of these were a daylight shower telescopically detected and observed.

Table I	28,057
Table II	7,134
Table III	252
Perseid Epoch	12,703
Leonid Epoch	13,558
Fireballs	285
Grand Total for 1933	61,989

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1934 February 17.

The Relation of Group to Solo Counts in Meteor Work

By C. C. WYLIE

Two determinations of the relative number of meteors seen by a single observer, and by a group, are known to the writer. One determination was made by H. A. Newton during the Leonid display of 1865. His figures are based on a simultaneous watch of different parts of the heavens by twelve observers. The other determination was published by Kleiber in the *Astronomische Nachrichten*, No. 2621. His figures are apparently based on forty-nine meteors observed during one and one-half hours. Kleiber's article is not available to us. We are indebted to Professor Joel Stebbins of the University of Wisconsin for a summary of the material.

For some years counts have been made in Iowa on the Perseid and Leonid showers. They have been made systematically at Dubuque, Iowa, under the direction of Father J. A. Theobald of Columbia College. The Dubuque observers have kept a record of the group count, and also of a solo count made at the same time. The groups at Dubuque have varied from two to eight, five being the most common number.

Some group and solo counts have also been made at Iowa City, Iowa, under the direction of the writer. Throughout the 1933 Leonid shower, a group at Des Moines, Iowa, headed by Paul Annear, kept watch. The great majority of the material used here, however, is from Dubuque.

The table below shows the relative number of meteors observed by a single person and by groups of various sizes from one to eight. The relative numbers are given according to Newton, to Kleiber, and to the work in Iowa. For the Iowa work we give, first, the actual number from the counts, and second, the relative numbers according to a smoothed curve.

Number Observers	Newton	Kleiber	Iowa Observed	Iowa Smoothed
1	1.00	1.00	1.00	1.00
2	1.95	1.72	1.71	1.65
3	2.57	2.24	1.80	1.92
4	3.08	2.63	2.13	2.12
5	3.40	2.96	2.44	2.30
6	3.69	3.29	2.30	2.45
7	3.94	3.53	2.58	2.59
8	4.15	3.70	2.29	2.72

Newton assumed from his results that if the number of observers were indefinitely increased, the relative number would approach as a limit, about 7.40. Six observers would see half of the total. For the Iowa work, the relative num-

bers evidently approach a much lower limit, probably only a little over 3.00. The Iowa counts indicate that, with ordinary amateur observers, there is little gained by using a group of more than five.

University of Iowa, February 24, 1934.

Notes from the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, and H. H. NININGER, Secretary

Concerning the Origin of Meteorites

By FREDERICK C. LEONARD

In Russell, Dugan, and Stewart's "Astronomy," Vol. I, §154, entitled "Constitution of the Earth's Interior" (pp. 130-133), it is stated that "The occurrence of metallic iron in meteorites (§531) makes it probable that this dense substance [at the center of the earth] is iron or an alloy of iron and nickel. This was first suggested by Wiechert in 1897. The latest evidence indicates that this metallic core is about 4000 miles in diameter, and of a density ten to twelve times that of water (which nickel-iron might attain under the great pressure). Adams and Williamson conclude that a layer of mixed iron and rock, about 1000 miles thick, surrounds the core (Fig. 56); Jeffreys (1926), that the transition to the rocky crust is abrupt. Most of this crust is composed of heavy basic rocks, and its mean density is about 4. The outer granitic layer, of density 2.7, appears to be only about 40 miles thick."

The following paragraphs are quoted from Moulton's "Introduction to Astronomy" (Revised Edition), §209, "Theories respecting the Origin of Meteorites" (pp. 345-347): "Chamberlin has maintained that meteorites may be the débris of bodies, perhaps of planetary dimensions, which have been broken up by tidal strains when they have passed some larger mass within Roche's limit. When suns pass by other suns, it is probable that at rare intervals they pass so near each other that their planets (if they have any) are broken up. More rarely, the suns themselves may be disintegrated. Indeed, this may be the origin of all cometary and meteoric matter. Whether it is or not, there is here a possibility of disintegration which must be taken into account in any theory of cosmical evolution. . . . . .

"The suggestion that a meteorite may be a fragment of a world which was disrupted before the origin of the earth makes some demands on the imagination, but it seems no more incredible to us than seemed the suggestion to our predecessors a century ago that great mountains have been utterly destroyed by the rains and snows and winds."

In the two foregoing excerpts is found material for a possible theory of the origin of siderites, siderolites, and aërolites. If meteorites are the remains of disintegrated bodies of planetary size, as Chamberlin once contended they are, and if planets—in our own solar system and elsewhere—are constituted as the earth is supposed to be, according to the ideas of Wiechert, Adams, Williamson, and Jeffreys, it is tempting to conclude that siderites represent the products of the disrupted nickeliferous iron cores of defunct worlds, siderolites, the remains of their intermediate iron-rock shells, and aërolites, the débris of their outermost stone strata. While this suggestion is obviously not intended to account for the genesis of all meteorites, and is probably not free from certain technical objections, it may be regarded as a plausible hypothesis of the origin of some meteorites, and moreover as a reasonable explanation of the existence of three main varieties

of specimens—siderites, siderolites, and aërolites.

Just as many meteorites of interplanetary origin may be residua of the primordial nebula from which the solar system conceivably developed, if they are not bits of former comets or of planets antedating the present family, so may some meteorites which have invaded the solar system from the starry realms, be left-over products from the evolution of other suns and planetary systems or of even the galaxy as a whole. In view of the abundance of dark absorbing matter in the sidereal system, in the guise of interstellar clouds and of non-luminous diffuse nebulae, it can hardly be doubted that innumerable small bodies, similar to those which circulate around the sun in such aggregations as the zodiacal light, the gegenschein, and meteoric swarms, are dispersed throughout interstellar space. When these interstellar meteorites or meteoroids—for such they are—come within the gravitational domain of the sun, they are drawn into the solar system on hyperbolic orbits, on rare occasions to be intercepted and appropriated by the earth itself.

The Nininger Survey Reports Progress

By H. H. Nininger

In 1923 the writer began a field search for meteorites on the assumption that it would be possible to demonstrate that extra-mundane matter was more abundant in the soil than had been assumed by the scientific world.

By the year 1925 a degree of success had been attained which seemed to warrant, not merely a continuance of this effort, but an expansion of it, and, consequently, a feeble attempt was made to systematize the work. Shortage of time and the lack of funds, however, compelled the restriction of the search to very narrow limits. Nevertheless, evidences of the soundness of our assumption were repeatedly brought to light in the course of these years.

When the Nininger Laboratory was established in 1930, the supervision of this work was undertaken as a part of its program and the field work was reduced to a definite plan of survey. By systematically covering certain defined areas, it was thought possible that eventually we should be able greatly to improve upon the earlier estimates of the amount of undisintegrated meteoritic matter on the surface, and in the soil down to the depths reached by cultivation.

Obviously any survey of this kind can never be made complete, since meteorites, except in the case of siderites, probably arrive on the soil, for the most part, in the form of dust or very small particles, which within a few years disintegrate to an extent which destroys all marks of identification. We are limited in our method of search to those masses which are of sufficient size to attract the attention of the tiller of the soil. Our plan has been, however, to do all that is possible by way of the recovery of sizable fragments in the selected territory. After that it will probably be feasible to arrive at satisfactory estimates regarding the amounts of finely divided particles by means of another type of survey.

The method employed in our survey has been to conduct an educational campaign among the farmers of selected areas, and to make this effort effective by offering money for any meteorites which may be recovered. As may be supposed, the economic incentive is quite necessary to enlist a sympathetic attitude, on the part of the farmers, toward the program. Even then it is only partially effective, as it often fails to free our announcements from ridiculous interpretations. Not a few instances have been met with in which persons have destroyed or failed to report meteorites in the midst of communities where our campaign was being vigorously pressed. In some cases the owners of these stones were in dire need

of the money offered for them. Just now there comes to mind a case where a farmer of average intelligence in his neighborhood, knowingly threw away three meteorites and refused to send in a fourth, even though he had heard that we were paying good prices for them! At the same time, his children did not possess clothes fit to enable them to attend the rural school without a feeling of embarrassment!

Our most effective method of carrying on the program among rural peoples has been by lectures in the schools, and by illustrating the lectures with specimens of real meteorites of the various types. Talks to the parents are even more effective where opportunity is afforded, but it is much more feasible to reach them through their children in the schools. Here the alert teacher at once sees an opportunity to embellish the regular program by a truly educational feature and at the same time to lighten his or her own load of instruction.

Newspaper announcements have proved of use in many instances, but unfortunately (or perhaps, from another viewpoint, fortunately) the farmers have come to regard newspaper announcements more or less skeptically and frequently we have found them ineffective. A case met with on a recent field-trip is an impressive example: Owning and farming a section of wheat land, a graduate of a leading agricultural college was found to have been carrying meteorites out of his fields over a period of more than fifteen years and disposing of them as nuisances. He was doing this notwithstanding the fact that several announcements had been made in the local papers to the effect that these stones were salable. Curiously enough, and quite unusual, was the fact that this man *knew* they were meteorites! There were more than a dozen stones thus disposed of, some of which could not be recovered by this enthusiastic searcher after he had been apprised of their value!

When our search was begun more than ten years ago, the writer said to Dr. George P. Merrill of the U. S. National Museum, that twenty years should be sufficient to justify some announcement of our results. We still believe that it will be several years before any final quantitative announcement can be made with assurance. However, the work has progressed beyond the point where its justification can be questioned. Already from an area of 35,000 square miles, very inadequately covered as yet, more than 1¼ tons of meteorites have been recovered. It is the writer's belief that this amount will be more than doubled from the designated territory before the possibilities of this type of survey have been exhausted. Even this weight, however, is 7000% greater than the average weight of meteorites per unit of area of the earth's surface as recorded at the time the survey was begun. Those earlier recorded figures have several times been used by geologists and astronomers in their calculations as to the importance (or rather the unimportance, as they interpreted it) of the cosmic factor in earth growth. Incomplete as are our results at the present writing, we respectfully submit them as an indication of what may be accomplished in this line. We cordially invite other workers to join in a search which promises to yield very significant data in the fields of astronomy and geology, or, more exactly, in the field of meteoritics.

Miscellaneous Notes

The following five new Committees of the Society are being appointed by the Executive Committee of the Council: a Committee on Classification, a Committee on Discovery, Identification, and Analysis, a Committee on the Relations between Meteors and Meteorites, a Committee on Collections, and a Committee on Meteoritic Features of the Earth's Surface. It is expected that all the appointments to

these Committees will be completed in time for the personnel of each to be announced in the *Notes* in the April issue.

The Secretary of the Society is making a trip to the East in the interests of research on meteorites. He has been engaged to lecture before the Cosmos Club, in Washington, D. C., the arrangements for the lecture having been made by the Carnegie Institution of Washington. He is scheduled to deliver several other lectures also, *en route*.

Leaflet 61 of the Astronomical Society of the Pacific (Merchants Exchange Building, San Francisco, California) for February, 1934 (4 pp.), entitled "Visitors from Cosmic Space," is a brief popular account, by the President of this Society, of the subject of meteorites.

Secretary's Address: The Nininger Laboratory, 1955 Fairfax Street, Denver, Colorado.

Editors' Address: Department of Astronomy, University of California at Los Angeles.

A Slowly-Moving Meteor.—On Saturday night, January 20, 1934, several of the fellows and I were standing in front of the gymnasium facing Howard Hall. Suddenly to the west of the tower on the top of the hall a meteor flared. It first showed just below the Little Dipper and floated slowly in an arch on past the Big Dipper and disappeared below the horizon. The thing lasted at the least eight seconds or more. The speed of the meteor was the interesting part as I have never seen one that moved so slowly.

W. R. WAGNER.

Berea College, Berea, Kentucky.

A Double Fireball.—I wish to report the observation of a double fireball in daylight. This morning (January 25, 1934) at about 9:23 A.M., E.S.T., Mr. N. E. Lindenblad, radio engineer of R.C.A. Communications, Inc., at the Rocky Point, New York, Radio Station, observed a brilliant double fireball and reported the details to me within five minutes of the fall.

The sun was shining brightly, the sky was cloudless, and while observing the manoeuvers of two planes in this vicinity the meteors drew his attention though the planes were not in that direction. The meteors appeared about 10° south of west at an angle of 45° to 50° to the horizon and travelled in parallel paths, slightly curved in appearance to the point of disappearance, due northeast and about 10° above the horizon.

The balls appeared to be nearly alike in size, of a brilliant blue-green color (each fully as bright as Venus at the brightest). They had white wavy, streaming tails about 1½° in length. They were about ½° apart at first, the lower one slightly in advance and at disappearance were about 2° apart. There was no smoke trail and no noise heard. The duration of sight not over 5 seconds.

The location of this point from the U. S. Coast and Geodetic Survey maps is Latitude N 40° 54½′ and Longitude W 72° 56½′.

R. E. FRANKLIN.

Fireball Observed.—A fireball appeared at 11:30 P.M., C.S.T., about seven degrees east of the star η Ursae Majoris; it traveled through the constellations of Canes Venatici and Bootes, and disappeared within a degree of the northeastern horizon. The whole appearance lasted about two seconds. The fireball was as bright as the moon, which was a little past the quarter at the time. It was greenish-white in color and left a conspicuous reddish train. The angular diameter

of the fireball was about two-thirds that of the moon. The date was January 25, 1934; the place of observation was a few hundred yards north of the village of Christine.

NOAH W. MCLEOD.

Christine, North Dakota, January 26, 1934.

Notes from Amateurs

Astrolab Progress Report

In the little over a year of its existence Astrolab has had as one of its aims the exchange of information among a number of amateur astronomers and lens makers all over the world. Where most of the contacts are made by means of letters, bulletins, and pictures, it is quite a problem to find a medium of exchange that will be the most efficient.

Someone has said that each picture is worth 10,000 words, and Astrolab has been endeavoring to use as many pictures as possible. The Astroscope is particularly well suited to line drawings, and very recently we have been using blue prints more and more. However, even a photographic print does not give as much detail as the same negative does when transferred on a slide and projected for careful examination.

A few nights ago a group of the local Astrolaborers came over to 10728, and the first of the sixty-one slides now belonging to the Astrolab collection were thrown on a quickly made screen. Sixty negatives have been secured as a basis from which to build a collection of astronomical slides for interchange and loan among members. Two of the fellows that were over had been busy during the previous week trying their hands at making slides. According to one of them, it is a very sad business—a slide looks beautiful until you put it under the magnification of the projector, and then all kinds of defects such as dust, finger prints, lint, etc., show up as big as mountains. Much good natured criticism and favorable comments were made on each fellow's handiwork. There was the Andromeda Nebula—someone recalled a recent lecture and a report from *Science* of the discovery of many times more nebulae in a given area than had heretofore been known. One of the most interesting of these slides was made from a drawing of Herschel's forty-foot long telescope, and immediately after showing it on the screen, a slide of Astrolab's portable Polar Bowl Mounting was put up for criticism.

It is planned that before long the Polar Bowl will be equipped with a clock drive accurate enough to permit the combining of the hobbies of photography and astronomy. What fun when we can make our own Orion Nebula negatives and show them for the benefit of fellow Astrocraftsmen all over the world.

The Polar Bowl Mounting is designed to carry a camera directly in the declination bearing, and as the first one of these mountings is already in use for visual work, and members are working on the design of the clock and gears, it probably will not be long before some ambitious member takes a shot at the Moon, Mars, or Jupiter.

It is planned to make up extra slides from this nucleus of sixty negatives in order that other collectors may exchange slides with us. Eventually, if the idea meets with general approval, the astronomical slides belonging to Astrolab should grow to several hundred. Any member, then wishing to give a talk, can borrow these slides as he will have a member ownership in them. If you are interested in this idea and would like to coöperate, send us a blue print and list of the slides

you have for exchange, and we will loan you a blue print and mimeographed list made up for this group of sixty negatives.

TRANSLATIONS OF PAPERS ON OPTICS.

A great deal of time and effort has been spent by several of Astrolab's translating committee on the translation of "Researches in Geometrical Optics, Part II, Theory of the Reflecting Telescope by K. Schwartzschild." WHF has completed the translation of the entire paper and has made seventeen copies. These will be for rental from the Astrolab Library, and if some individual particularly wishes to own a copy a few will be sold. This translation, with complete formulae and illustrations covers thirty-one pages, and represents careful work and effort on the part of WHF. Quoting from the translation: ". . . the problem is considered for a system made up of two mirrors, which, while giving not only sharp focus, will also in addition fulfill the sine condition. There is also considered an aplantic telescope system (using Abbe's nomenclature) that is free from spherical aberration and coma. This mirror section results from a differential equation which, strange to say, lends itself to algebraic integration."

Schwartzschild's first paper has been translated but has not been prepared for distribution, as it is more elementary and less directly applicable to the building of a telescope. However, if there should be sufficient demand for the translation, copies will be made.

Translation of "The Telescope of Newton and The Aplanatic Telescope, by Henri Chrétien" is also complete, and we should like to have some one volunteer to re-type this 18-page article for the making of duplicate copies.

Astrolab invites the correspondence of interested observers. For additional information about this coöperative group see previous issues of POPULAR ASTRONOMY, or write

L. I. BUTTLES.

10728 S. Artesian Avenue, Morgan Park, Chicago, Illinois.

Amateur Telescope Makers of Chicago

The Amateur Telescope Makers of Chicago held their monthly meeting in the Adler Planetarium and Astronomical Museum, Chicago, on Sunday, February 4, at 2:00 P.M. The program was an open discussion of new and untried ideas.

Professor Arthur Howe Carpenter opened the discussion with an idea for a 10-inch telescope F.5, with a 5-inch flat placed at half the focal length and the 10-inch mirror pierced for the eyepiece. This would have a tube about 2 feet long making a very rigid and compact instrument. He also said that a finder might be placed in the axis of the telescope by piercing the 5-inch flat for the finder objective. The same eyepiece could be used for finding and observing by racking it from one focus to the other. He also suggested a unique method of testing zones by means of two diaphragms placed near the knife edge.

George E. Warner proposed a device for alining a telescope with the meridian and pole by placing a telescope with reticle in the polar axis.

Gerald E. McCord inquired about the Herschellian telescope and Warner amplified the idea by suggesting an off axis paraboloidal mirror and demonstrated the possibility of using the latus rectum portion of the paraboloid to produce a telescope which could be used with a reflecting eyepiece.

Interest was expressed in the aluminum coating of mirrors. Leroy Clausing is building an evaporating apparatus which will enable him to coat mirrors up to 15 inches in diameter.

WM. CALLUM, *Secretary.*

1319 W. 78th Street, Chicago, Illinois, February 15, 1934.

Collimation

The alignment of the prism of the Newtonian is a matter of some difficulty. Accuracy is important to performance, however, and pains will be fully repaid in better definition. The following method is offered as a substitute for the rough procedure usually suggested.

It is presumed that the prism is so mounted that it may be conveniently adjusted.* Fitments that do not permit easy motion in all required directions are a sore trial to patience. Possibly the best arrangement is the familiar one of supporting the prism by means of four webs terminating in slotted holes in the wall of the telescope tube. If the prism can also be rotated around the axis of the tube, the adjustments are complete.

The prism is first centered with respect to the telescope tube. This can be done with sufficient accuracy by measurement. It is also adjusted so that it is roughly central to the adapter opening, judged by looking through the eye end.

A "target" is now prepared. A hole large enough to fit snugly over the inside end of the adapter is cut from a white card, and heavy black concentric circles, about ⅛ inch apart, are ruled outside the cut-out "bull's eye." This card is slipped over the inside end of the adapter, facing the prism.

If the cell end of the telescope tube is now covered with a dark cloth (the mirror having been removed), it will be possible to see, on looking into the adapter, a faint reflection of the target in the nearer *square* face of the prism. An eyepiece, lenses removed, should be slipped into the adapter for this purpose. Adjustment of the prism is now made, so that the reflected system of circles is centered on the *square* face of the prism. This is easily done by moving the prism until one of the circles is tangent to all four edges.

For the dark cloth over the cell end of the tube, another is now substituted which will admit enough light so that the circular opening of the tube can be seen reflected from the hypotenuse side of the prism. With a juggling of the illumination, it will be possible to keep the reflected circles of the target still in view.

The adjustment is now completed by moving the prism up or down the axis of the telescope until the image of cell end is concentric with the system of circles reflected from the target, *the latter being, at the same time, kept centered in the square face of the prism.* This requires some sleight of hand, but the trick is soon learned.

No attempt should be made to center either the reflection of the target or the image of the end of the tube in the hypotenuse face of the prism as seen through the adapter. Neither, when the adjustment is perfect, is centered in the hypotenuse face, as a little geometry will show.

The principal mirror is now collimated by its own leveling screws, using one of the usual procedures, and the job is done.

CHARLES W. ELIASON, JR.

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*It is also assumed that the prolongation of the axis of the eyepiece intersects the axis of the telescope tube, and at right angles.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Venus and Life

If life, such as we know it, is to exist upon a world, there must first be the basic substance, protoplasm, out of which all organic life is constructed. Protoplasm in turn must have for its own continued existence, the presence of liquid water. Life cannot exist solely upon steam or ice; it must possess a stable chemical environment such as is afforded only by water in the liquid form with which we are familiar.

Here, at once, in the study of the planet Venus, we come upon a stumbling block. The most recent work of St. John and Nicholson at Mt. Wilson Obervatory indicates that there is less than one millimeter of precipitable water vapor in that section of the upper Venusian atmosphere which we see. This amount allows for less than an equivalent of one meter of pure oxygen in the atmosphere traversed by the reflected rays of the sun which enter the spectroscope. This, it is obvious, is all too small an amount of oxygen when diffused throughout the entire atmosphere of the planet, for the sustenance of organic or vegetable life. Again, due to necessity for the equal distribution of oxygen in the atmosphere, the existence of a minimum amount above the clouds would possibly indicate little below them. It is possible, however, that the reflecting layer of the atmosphere is composed of cirro- tratus clouds or haze, and thick clouds of dust, which do not allow the sunlight to penetrate beneath their surface to the water and oxygen which possibly lie close to the surface of the planet. Thus, the light we receive is only that reflected from the upper layers of the Venusian atmosphere, which, like our own upper air, contains but little oxygen and water vapor.

Russell has stated that the height of the planet's atmosphere is at least seven miles, and may well be twenty or thirty, as compared to the possible forty mile extent of our own. It seems probable from the recent photographic work of Ross and others, that the theory of another, cloud bearing layer of moisture underlying the present cloud strata and extending to about a mile above the planet's surface, is tenable.

It was calculated by Lowell that Venus owes four-fifths of her intense brightness to her dense atmosphere. This is corroborated by the low albedo, or reflecting power, of Mercury and the Moon which have no atmosphere, and the intermediate lustre of Mars which possesses some. This dense atmosphere on Venus would greatly modify the intensity of solar radiation which the planet receives upon its surface, causing that radiation to be only one and four-tenths times that received upon the surface of the earth. Thus, in general, the average temperature of the planet would not be so great as to be hostile to life, or to vaporize all the water which might be there.

Another important factor is that of the rotation period of Venus upon its axis. It was suggested by Schiaparelli and upheld by Lowell that the planet's period was identical with the period of its revolution around the sun, namely 225 days. Thus, the planet would keep one face toward the sun as does Mercury, the

other forever facing the icy depths of space. If this were the case, the lighted side would be boiling hot in the sunlight, and the dark face a region of ice and desolation, both singularly hostile to the development of any life. However, such a condition of rotation would cause a permanent hurricane system in the planet's atmosphere. The heated air on the side toward the sun would rush upwards violently, followed by an inrush of cold air from the dark side; this constant turmoil instituting violent dust and cloud storms. There is however, no evidence that we can perceive such storms.

Nevertheless, it *is* evident that the planet possesses an excesively long period of rotation. If the time of rotation were anything approaching our own twenty-four hour period, Venus would be flattened appreciably at the poles due to the centrifugal force throwing the matter down and out at the equator as during the planetary formation. However, there is scarcely any equatorial bulge or polar flattening. Its estimated polar flattening should be 1/275 of its equatorial diameter. No such flattening is observed, though it could be clearly found if present. The spectroscopic studies of Slipher at Flagstaff determine for the planet a long period, though one less than 225 days, and approaching more closely, thirty or forty days. Ross, from his photographs in ultra-violet light, which always show details present, compromises on a period of thirty days, thus substantiating Slipher's observed results.

In 1924 Nicholson and Pettit observed that the dark side of Venus during its phases is nearly uniform in temperature from west to east, and nearly the temperature that the earth would appear to have if viewed from another planet. Obviously, this could not be so without fairly rapid rotation, and the period of thirty days seems to allow for this temperature since Venus is so much nearer the sun than we are. Therefore, if the planet *does* rotate with such a period, its surface conditions are fairly stable and favorable to the development of life.

The most important and significant work seems to be that done recently by Adams and Dunham at Mt. Wilson in investigating the infra-red spectrum of Venus. This research, accomplished with the 100-inch reflector and a plane grating spectrograph of nine feet focus, seems to establish quite definitely the existence in the planet's atmosphere, of an amount of carbon dioxide equivalent to many hundreds of feet of the gas at atmospheric pressure. This has been confirmed by passing light from the sun through 130 feet of carbon dioxide, in a tube, at a pressure of ten atmospheres. The spectrogram thus obtained resembles very closely the spectrograms made of the light from Venus, showing the carbon dioxide absorption bands. The significance of the existence of this gas in the atmosphere is, of course, that, since the gas is given off by the respiration of plants and animals as well as by other processes, its presence may well denote a life of some sort upon the surface of the planet.

Of course, there remains the noted absence of oxygen in large quantities in the Venusian atmosphere; though, as before stated, it may lie close to the surface of the planet and beyond our present ken. In the case of the earth, our oxygen might have been the direct result of the evolution of life upon the surface, instead of life as the result of oxygen; and where the one is, the other is an inevitable result. We may even suspect that life is even now beginning to form on the surface of Venus, and is, in its evolution, producing both carbon dioxide and oxygen.

In regard to the possible source of the original protoplasm upon the planet (if it exists at all), we may apply Chamberlin's hypothesis of the formation of the solar system; that since if the Earth and Venus were both originally knots of nebulous, heavy, refractory material thrown off from the same source, the sun,

we may consider that they possess, in general, the same physical and chemical characteristics and composition; and, other factors being equal, we may look to the "Evening Star" for the eventual development and evolution of organic life not greatly dissimilar to our own.

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The Law of Physical Formations on the Earth

To the ancients the phenomena of Venus and Mercury as evening and morning stars were long a puzzle. Later the irregularities in the motions of the planets in the Ptolemaic system were a puzzle. Later both of these puzzles were solved and we think how simple the solution. On this earth we have the physiographic features, such as the direction of shore lines, streams, mountain ranges and divides, glaciers (ice rivers), terminal moraines, drumlins, boundaries of swamps, marshes, and forests, and geological formations, the alignment of lakes and forests some distance apart, of coal beds and their boundaries, of iron ranges and iron deposits, of deposits of other ores, and possibly joints and faults in rock formations that have been puzzles, but which follow a very simple law. It is that of making an angle either with the meridian or with a small circle of the earth that is parallel to the equator at the point of locus on same equal to that of the inclination of the earth's axis to the ecliptic. This gives us four fundamental lines, and as each line has two directions we have eight courses, as N 23½° E (or S 23½° W), N 23½° W (or S 23½° E), N 66½° W (or S 66½° E), and N 66½° E (or S 66½° W). Along those courses our divides and mountain ranges and streams and shore lines go as a rule. I do not mean that we can put a straight edge to a stream or divide or mountain range and the straight edge will be one of the above directions, nor do I mean that when a stream, etc., starts out say S 23½° E it is going to keep on going that way, but any change that it makes will be along one of the other seven remaining courses. A stream may appear on a map as running, say northeast, but the course is made up of numerous short segments running as a rule N 23½° E, and N 66½° E of about equal length. The same thing applies to all the earth's features named above.

Consider a right-angled triangle made out of a piece of clear photographic film with the one angle equal to 23½° and the other necessarily equal to 66½°. If we use this on *segments* of coastlines, rivers, mountain ranges, divides, it will not take long to note that they take one of the directions given above, sometimes the segments are quite long, otherwise quite short. Thus along the Mississippi River west of the state of Mississippi we have two long segments bearing S 23½° W and a shorter one S 23½° E and the whole length of the above being made up of numerous short segments whose course is one of those given under the eight fundamental directions.

If we use a map of Wisconsin or Minnesota or the western part of the United States, we can not help but see how the small lakes coincide with these lines, being in many cases strung along like a string of beads. Also the latter remark can be made concerning the national forests in Western United States. The terminal moraines, the direction the glaciers moved, and the drumlins left by them follow this law very closely in Wisconsin. Like the lakes the drumlins in many cases seem like a string of beads.

The geological formations, such as the boundaries of the granite, sandstone, and limestone formations in Wisconsin, also the marshes, swamps, prairies, and forests seem to agree with this law. It will readily be seen that the center line of Lake Michigan bears N 23½° E, of Lake Erie N 66½° E, of Cuba S 66½° E, and

of Madagascar N 23½° E and so on the list might be continued. And as the inland lakes seem to arrange themselves like strings of beads so do the islands in the oceans seem to arrange themselves along these lines. As we observe breaks in coast lines, so are they visible in the lines of islands and lakes and rivers, but these breaks are made along one of the lines named above. Thus the prevailing direction of the south coast of England is N 66½° E but the coast line is not a straight line but a series of parallel lines with small jogs at some other of the courses named to same. We note the same thing in the case of the iron ranges in Minnesota where the range at Hibbing and the one at Cuyuna make a jog but both bear N 66½° E, as do those in northern Wisconsin. We also note this preference, to some extent, in contours, isotherms, isogonic lines, ocean currents, to conform to the above directions.

All of the phenomena above mentioned militate against the idea that the glacial age resulted from a change in the inclination of the earth's axis. And further proof is the fact that post and pre-glacial streams seem to obey the same law. And it would seem that if there ever was a change the joints and faults in the rock should show it, and the amount of it. It will easily be seen that a course that bears N 23½° E is a segment of a great circle that is tangent to the two polar circles, the southern point of tangency being 180° in longitude from that of the northern point and a great circle at right angles to this great circle will be tangent to the two tropical circles at points differing 180° in longitude and the one will correspond with the position of the sun on the longest day of the year in the southern hemisphere on December 21. Likewise, we have a similar one in the line N 23½° W which represents the longest day in the northern hemisphere on June 21.

These four lines may be considered the four fundamental lines of nature on the earth. We have angles between them of 47° and 43°.

In the *North American Almanac* for 1931 on page 166 is an illustration of Widmanstatten figures of a meteorite. A casual observer will be very apt to note the parallelism of the lines thereon in three directions, parallelism similar to the lines on the earth, and he will note wider spaces between them where lines in a certain direction do not go. He will also note incomplete isosceles triangles where the angles are 47° and 66½° or parallelograms whose angles are 66½° and 113½°. According to Schiaparelli's map of Mars, many of the lines shown thereon seem to agree very well with those of the earth. The same can be said of lines on many of the drawings of Mars by Pickering and others. The inclination of Mars is supposed to be very near the same as that of the earth.

It might be possible by looking along these lines from known deposits of minerals to find other deposits. Thus we have the lead and zinc mines in southwestern Wisconsin bearing N 23½° E from the Ozarks in Missouri, and the iron deposits at Black River Falls, Wisconsin, S 23½° E from the Hibbing deposits. On lines radiating out from these deposits in the eight fundamental directions other deposits might be found. And in these depression times it might be very useful to use this in regard to gold deposits, to help bring back prosperity. Of course we must always remember that there may be a jog in the line. If a person is more interested in oil it might be mentioned that the Amarillo, Texas, oil field is S 66½° W from the oil field in western Pennsylvania, and it is possible that many oil fields may be found yet on this earth in places now not dreamed of by applying the suggestions above given.

Perhaps I should here mention that the only reference I have seen relating in any way to the topic under discussion is an article by William Taylor Jordan in

POPULAR ASTRONOMY, Volume 20, pages 296 and 343 (1912), but he claims nothing regarding lines bearing 66½° from the meridian, nor for changes in direction of coast lines or divides, but considered it as a straight line, or a complete circle, while I believe the laws as I have stated them apply to every case, and to many features of the earth's surface not mentioned by him. Great credit is due him for the ideas that he there presented.

DAVID A. BLENCOE.

Alma Center, Wisconsin.

Zodiacal Light Notes

By FRANKLIN W. SMITH

The evening Zodiacal Light was observed on February 10, from 7:10 to 7:20 E.S.T. The northern edge of the light cone passed near α and γ Pegasi and about 2° south of γ Arietis. The southern edge passed perhaps halfway between η and ι Ceti, and just north of μ Ceti. The apparent apex was about 5° southwest of the Pleiades. The elongation of the apex from the sun was therefore about 92°, and the axis of the cone was practically coincident with the ecliptic. At a point on the axis and at an elongation of 45° from the sun, the brightness, as determined by means of the surface photometer, was 1.40 times that of the background sky.

The Gegenschein was of course invisible during December and January while it was crossing the Milky Way. It has now passed into Leo and so may be seen under rather favorable conditions. It was observed at 11:00 E.S.T., February 13. It appeared to be perhaps 10° or 15° in diameter, and its center was estimated to lie on a line from Praesepe to Regulus and at a point about two-thirds of the distance from the former to the latter. Observing conditions will remain favorable as the Gegenschein crosses Leo and passes into Virgo, but after that it will be too far south to be well seen by northern observers.

407 Scott Avenue, Glenolden, Pennsylvania, February 17, 1934.

General Notes

Dr. Harlow Shapley, director of the Harvard College Observatory, has been awarded the gold medal of the Royal Astronomical Society, London, for his work on the structure and dimensions of the galactic system. On May 11 Dr. Shapley will deliver the annual George Darwin Lecture to the society. (*Science*, January 26, 1934.)

Dr. Harlow Shapley delivered a lecture under the James Arthur Foundation of New York University, on the subject "On the Lifetime of a Galaxy," in the Auditorium of the Gould Memorial Library, University Heights, Tuesday evening, February 6. This was the third lecture in this series.

Sir Arthur Stanley Eddington has been appointed Messenger Lecturer at Cornell University this year. He will give a series of twelve lectures on "New Pathways in Science," beginning on Monday, April 9. He will give three lectures a week, on Monday, Wednesday, and Friday afternoons, and will conclude the series on May 4. The titles of the lectures are as follows: "Science and Experience," "The End of the World," "The Decline of Determinism," "Indetermin-

ism and Quantum Theory," "Probability," "The Constitution of the Stars," "Cosmic Clouds and Nebulae," "The Expanding Universe," "The Constants of Nature," "The Theory of Groups," "Criticisms and Controversies," and "Epilogue." (*Science*, January 26, 1934.)

Bud Wiswell, as president of the Science Club of the Beverly Hills High School, Los Angeles, conducted the affairs of the club in such a commendable manner that as a consequence he has been given a year's subscription to POPULAR ASTRONOMY by the club. This was considered a fitting reward because of his special interest in astronomy.

Mr. George C. Blakslee, photographer for the Yerkes Observatory since 1916, retired from active service on January 1. Mr. Blakslee's reproductions of astronomical photographs made at the Yerkes Observatory, in the form of lantern slides, prints, and transparencies, are known throughout the world. Mr. E. L. McCarthy, a graduate of Cornell University, has been appointed as a successor to Mr. Blakslee. In coöperation with the University of Chicago Press, an effort is being made to increase the educational value of the lantern slides distributed by the Yerkes Observatory.

The Rittenhouse Astronomical Society of Philadelphia held its monthly meeting in the hall of The Franklin Institute, Twentieth Street and the Parkway, Tuesday evening, February 13. The program consisted of an address on the topic "Tides in Land, Sea, and Air" by Dr. Harlan T. Stetson, Director of the Perkins Observatory, Ohio Wesleyan University.

The Yerkes Reflector Resurfaced.—Through the coöperation of Messrs. Anderson, Pettit, and Strong of the Mount Wilson Observatory and of the California Institute of Technology, the 24-inch concave mirror of the Yerkes Observatory and its Newtonian flat, have recently been coated with aluminum. Efforts are being made to develop the necessary technique for coating the Texas 80-inch with aluminum or with some other highly reflecting metal, by the process of evaporation.

The McDonald Observatory is now under construction on Mount Locke, near Fort Davis, Texas. Professor G. Van Biesbroeck of the Yerkes Observatory spent several weeks at the site during the months of November, December, and January and fixed the position of the piers. Concrete work on the piers has now been completed. Actual steel construction on the mountain will begin approximately on May 1. The problem of the driving clock is being investigated by Messrs. Burrell and Moffitt, who have recently visited the McMath-Hulbert Observatory of the University of Michigan, for the purpose of inspecting the driving mechanism used at that institution.

Eugenio Rignano Prize.—A few years ago the publication "Scientia" announced a prize to be awarded in memory of the former editor of that magazine and bearing his name. The award, consisting of ten thousand Italian lire, was to be made for the best dissertation on "The Evolution of the Notion of Time," representing the phase of philosophical study to which Eugenio Rignano devoted his principal energies. Thirty-five essays were submitted and entrusted to a committee whose duty it was to evaluate them and decide upon the award. The conclusion of the committee recently announced is that the prize should be divided between

Sigismund Zawirski, Professor of Methodology and the Theory of Science at the University of Poznan, and Giovanni Georgi, Professor of Mathematical-Physics at the University of Palermo.

Book Reviews

"Where is Science Going?" by Max Planck, translated by James Murphy. (W. W. Norton & Co. $2.75.)

This book, comprising a prologue by Einstein, a biographical sketch of Planck by the translator, six chapters by Planck himself, and an epilogue, and all encompassed in 221 pages, is longer than it looks. It is the sort of a book which stimulates,—nay, necessitates,—thought, and thinking is for most of us a slow and laborious process.

A summary of chapter headings will indicate the scope of the book: Fifty Years of Science; Is the External World Real?; The Scientist's Picture of the Physical Universe; Causation and Free Will: the Problem Stated, the Answer of Science; From the Relative to the Absolute. And right at the start let us warn those who are rejoicing in Heisenberg's Principle of Indeterminacy and interpreting it as Freedom of the Will. Such will receive scant comfort from Planck.

A resumé of the progress in physical science since 1880, though limited almost exclusively to German progress, furnishes the scientific-historical background and shows how the introduction of the quantum theory has given rise to our present predicament. To quote from Planck's own statement of the problem: "It is not merely that the claim to reliability put forward by physical science is questioned from the outside; but even within the province of this science itself the spirit of confusion and contradiction has begun to be active. . . . Hitherto the principle of causality was universally accepted as an indispensable postulate of scientific research, but now we are told by some physicists that it must be thrown overboard. The fact that such an extraordinary opinion should be expressed in responsible scientific quarters is widely taken to be significant of the all-round unreliability of human knowledge."

Planck then takes up the Positivist doctrine that the accurate description of individual observations of natural phenomena is, and can logically be, the only end of physics, and shows what an inadequate foundation this furnishes upon which to rear the magnificent superstructure of science. We must, he says, accept the reality of the external world but at the same time recognize that this world is "not directly knowable." And thereby, says Planck, there enters into physical science the same element of irrationality and mysticism which permeates all other branches of human knowledge.

The apparent conflict between causal and statistical physics engrosses the author's attention for the greater part of the book. Is every individual event the result of some cause and the cause of some effect, which, if we but knew enough, we could predict? Or are the individual events free from any causal chain, and is it only the statistical average which may be said to obey a law? Planck answers "Yes" to the first question, but qualifies his answer by emphasizing the phrase "if we but knew enough," and attributes to God, and to Him only, the necessary omniscience. If, then, man is to have freedom of the will, it must be the result of the imperfection of his measuring instruments and the dullness of his sense perceptions which combine to prevent him from following the causal chain into the realms of the mind. At the same time, Planck seems a bit inconsistent in assert-

ing that freedom of the will results from "the impossibility of the individual contemplating his own activity here and now under the light of the causal principle."

In the last chapter the author discusses the efforts of science to reduce measurements to absolute values, and deplores the popular interpretation of the theory of relativity as destroying every basis for such values.

As the originator of the quantum theory, Planck certainly ought to be in as good a position as any one to give a critical estimate of its implications. Any person who has read the books of Eddington, Jeans, or Reichenbach, and feels he needs an antidote, would do well to meditate for a time with Planck. R.B.S.

Makers of Astronomy, by Hector Macpherson. (Oxford: at the Clarendon Press. $2.50.)

Through the 240 pages of this small book, 58 great figures in the history of astronomy relive their lives for us. The life and accomplishments of each astronomer is condensed to a compact, logical, clear, readable story. Each history is complete in itself. Chronological order is the thing that ties together these separate histories as a unified whole.

Space necessitated the omission of many famous names for various reasons. The men, and one woman, whom the author selected are primarily astronomers, and astronomers whose work in the field of astronomy lends itself to descriptive narration. The author gleaned from the wealth of available material only that which would paint verbal portraits in the form of a story of the essential facts concerning each astronomer. The author makes no attempt at a detailed and exhaustive study of these makers of astronomy, nor of the larger canvas, the history of astronomy.

The revolutionary doctrines of Copernicus awakened the Middle Ages from their intellectual slumber and, once awakened, the Dark Ages became history and the scientific Renaissance was in progress. Copernicus stands on the threshold between the darkness of the Middle Ages and the gradual enlightenment of the years to come. It is with Copernicus that the author begins his excellent book. Such men as Tycho Brahe, Kepler, Galileo, Huyghens, Newton, Halley, Laplace, the Herschels, Olbers, Bessel, Le Verrier, Fraunhofer, Huggins, Hale, Russell, Schiaparelli, de Sitter, Slipher, Eddington, Shapley, van Rhyn, and many others follow. Each person's life and astronomical work is briefly, clearly, and entertainingly told.

Any person interested in astronomy—be he an astronomy student in college or an astronomy teacher, a research worker in the field of astronomy, or an amateur astronomer, or merely a person in pursuit of general knowledge—will find this book very much worth while reading, and will be glad to have it in his library. *Makers of Astronomy* is a welcome addition to the literature of astronomy.

F. L. S.

Lehrbuch der Astronomie, by Dr. Elis Strömgren and Dr. Bengt Strömgren. (Julius Springer, Berlin, Publisher. 30 marks.)

The appearance of this volume brings clearly to the attention of those who see the book another example of son and father following the same lines in scientific work. It is a fortunate situation, productive of excellent results, when the judgment and steadiness of ripened experience and the energy and enthusiasm of youth are focussed upon the same purpose. The volume before us affords concrete evidence of this.

The book proper consists of 493 pages. There is an appendix of 55 pages,

and an index of seven pages. In the preface the authors state that in the preparation of the volume they kept before them the purpose of supplying a connecting link between the rather extensive popular literature in astronomy on the one hand and the highly technical literature on the other. In carrying out this purpose the writers in some instances have found it advisable to present a topic in its simpler aspects and then, at a later point in the book, to take it up again for a more thorough consideration.

This volume contains chapters on several topics which are not treated in the ordinary textbook on general astronomy. Herein one finds an introduction to celestial mechanics, and to the two-, three-, and n-body problem, and perturbations. The discussion of these topics in the main part of the work is supplemented by numerical examples in the appendix. To the reviewer it seems that the authors have succeeded admirably in accomplishing the purpose they had in mind.

It is, of course, understood from the title that the text is in German. The style is easy, and the thought is clear throughout. The authors are deserving of hearty congratulations, and the book is worthy of high recommendation.

The Place of Observation in Astronomy, by H. H. Plaskett.

The above is the title of a pamphlet of thirty-two pages, issued by the Clarendon Press, Oxford, containing the inaugural lecture on April 28, 1933, as Professor Plaskett assumed his duties as Savilian Professor of Astronomy, successor to Professor H. H. Turner. It contains a summary, necessarily brief, of the present state of astronomical knowledge and belief. A comprehension of this pamphlet will put one into touch with practically all the ideas which have recently become current in this science.

On the basis of the discussion, the author concludes that observation and theory must go along side by side in order to promote the science most effectively. Ideally an astronomer should be both a theorist and an observer. As this is the case in very rare instances, it is necessary that the observatory be a part of a university where new theory is being evolved. Moreover, the observer must be supplied with adequate apparatus.

Because of recent grants these conditions are happily met in the situation at Oxford University.

This pamphlet may be purchased for seventy-five cents.

Southern Appalachian Observers.—Copies of Circulars 2, 3, 4, and 5, published by Mr. Sterling Bunch, 2650 Selma Avenue, Knoxville, Tennessee, under the above name, have recently been received at the office of POPULAR ASTRONOMY. Each consists of a large sized mimeographed sheet, and includes items of interest to amateur astronomers who may be desirous of carrying out some observational projects. These circulars discuss such observations as those relating to meteors, occultations, Zodiacal Light, which may be made with little or no equipment. We commend Mr. Bunch upon his enthusiasm and hope that he will be rewarded with the satisfaction of having stimulated an interest in the science of astronomy in many who have not before been acquainted with it.

The Amateur Astronomer, published by the Amateur Astronomers Association, whose headquarters are at The American Museum of Natural History, New York City, has now reached the beginning of its sixth volume. With this volume it has assumed a new, enlarged, and improved form. The present plan is to have four issues annually, corresponding to the four seasons; the dates of issue

to be the solstices and the equinoxes. Each number will consist of sixteen pages, reproduced by the photographic process instead of the usual printing from type. The winter issue contains much interesting material and some excellent photographs, and will doubtless be eagerly received and read by amateurs far and wide. It shows enthusiasm and vision on the part of those responsible for it, and points to a larger future for itself and the association which sponsors it.

Cubics.—Pocket tables for Cubics is the title of a leaflet copyrighted and issued recently by David Katz, 1224 Madison Avenue, South Milwaukee, Wisconsin. By means of these tables the solution of a numerical equation of the third degree can be obtained directly, avoiding the tedious computation of auxiliary quantities necessary without them. The classical theory relating to the cubic is presented and the tables adapted to it. The tables, it seems, would furnish valuable aid wherever the necessity of solving a cubic equation arises.

Annales Guébhard-Séverine.—A complimentary copy of the current issue of a serial publication bearing the above title has been received at the office of POPULAR ASTRONOMY. It is published once a year. The copy at hand is a pamphlet of some sixty pages, is the ninth in the series, and pertains to the year 1933. This copy contains five extended articles; three relating to the chemical-physical science, one to astronomy, and one biographical. The astronomical article is a study of the correlation between the number of sunspots and the quantity of rainfall in Switzerland, for the time interval from 1864 to 1930.

Copies of this publication may be had free of charge. One need only send a request to Institut Adrien Guébhard-Séverine, Seyon 4, Neuchâtel, Switzerland.

MIND

O Night, I entered your deep heart and wept
The littleness, the grandeur that were mine
Lost in blue dark and one with the divine!
Immeasurable fires of Cygnus kept
The Northern Cross aflame. Where the west slept
Arcturus blazed and Scorpio's curved line
Lit a dim south. On the lone hill's confine,
Atom infinitesimal, I crept.

Yet I am greater than all these. Ye bright
Planets and stars, I speak not for your mirth
Who am endowed with more than mortal sight:
A higher heaven gave my spirit birth!
Above our universe of dust, O Night,
My soaring soul is God, made man on earth!

LILIAN WHITE SPENCER.

1490 Stuart St., Denver, Colorado.

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